TELEPHONE NOISE MEASUREMENT AND MITIGATION

Purpose: The purpose of this addendum is to replace Appendix A to TE&CM 451, Telephone Noise Measurement and Mitigation, with this revised Appendix.

Attachment

APPENDIX A
NOISE INVESTIGATION GUIDE

1. GENERAL

1.1 This revision presents a step-by-step flow chart for noise investigations for use of craftspeople in the field. It is organized so that each page provides a single link in the total investigation which directs the user to the next link in the investigation.

1.2 It is essential that the results of all measurements be recorded for reference as the investigation progresses.

1.3 Figures and Tables are referred to as appropriate in the flow charts.

2. HOW TO USE THE GUIDE

2.1 The first measurements should be completed at the subscriber location. To reduce travel time the measurements shown below are best completed during this first visit of the investigation to the subscriber location.

2.1.1 If loop checking equipment is being used complete measurements covered by Charts 1, 2, 3, 4 & 7.

2.1.2 If a noise measuring set is used complete measurements covered by Charts 1, 2, 3, 4, 7 & 14.

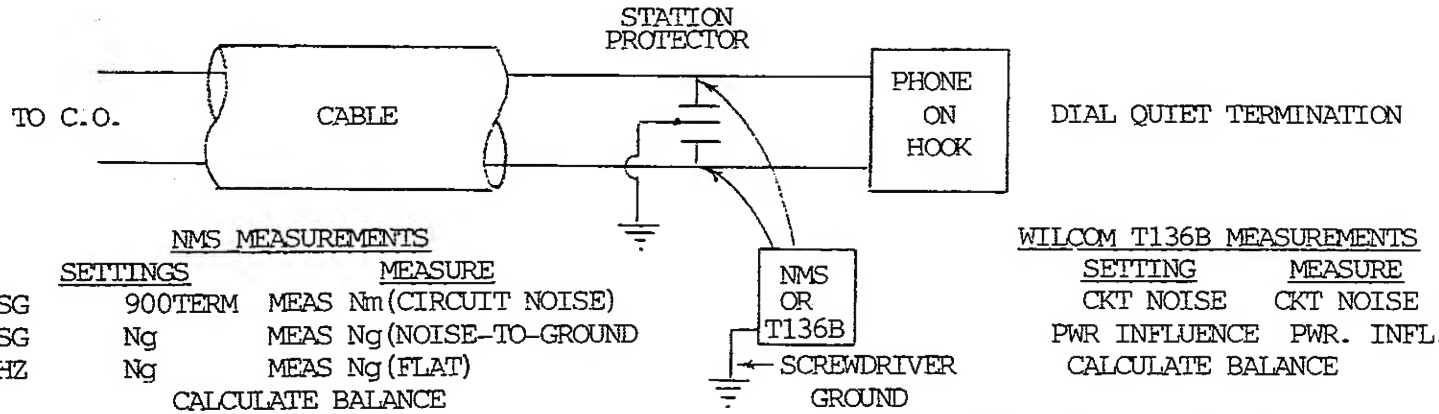
2.1.3 When a noise measuring set and spectrum analyzer is available complete measurements covered by Charts 1, 2, 3, 4, 7, 9, 14 & 17.

2.2 Start analyzing the recorded results at Chart 1. Then proceed to the Chart indicated below the appropriate level for the next step.

2.3 An * on the Chart indicates a measurement which may be completed with loop checking equipment.

3. TEST EQUIPMENT

3.1 The use of specific types of specialized test equipment manufactured by Wilcom Products, Inc. are described in the Noise Investigation Guide. These items are generally used throughout the Telecommunications industry and in some cases are, to the best of our knowledge, the only ones specifically designed for these applications. This is not an endorsement of these products by REA. Any test equipment capable of performing the measurements described may be used in lieu of those identified herein.



NMS MEASUREMENTS

SETTINGS		MEASURE
C-MSG	900TERM	MEAS Nm (CIRCUIT NOISE)
C-MSG	Ng	MEAS Ng (NOISE-TO-GROUND
3-KHZ	Ng	MEAS Ng (FLAT)
	CALCULATE BALANCE	

WILCOM T136B MEASUREMENTS

SETTING	MEASURE
CKT NOISE	CKT NOISE (Nm)
PWR INFLUENCE	PWR. INFL. (PI)
CALCULATE BALANCE	

BALANCE=PWR. INFL. - CKT NOISE
PWR INFL = Ng + 40

NOISE MEASUREMENT SUBSCRIBER LOCATION
FIGURE 1

Chart *1

SUB

*

See TE&CM Section 451.

Measure Power Influence C-Msg. Weighting

Test configuration shown on Figure 1, Page 53B.
See also notes on Page 53D.

Less Than 80 dBrnc	Between 80 & 90 dBrnc	Over 90 dBrnc
Go To Chart 2	2 9	14

*Measurements may be completed with Loop Checking equipment.

SAVE A TRIP

While at the subscriber location don't forget housekeeping of protector.

Check:

Station protectors: Kill insects and destroy eggs. Remove webs and nests. Note evidence of corrosion and clean.

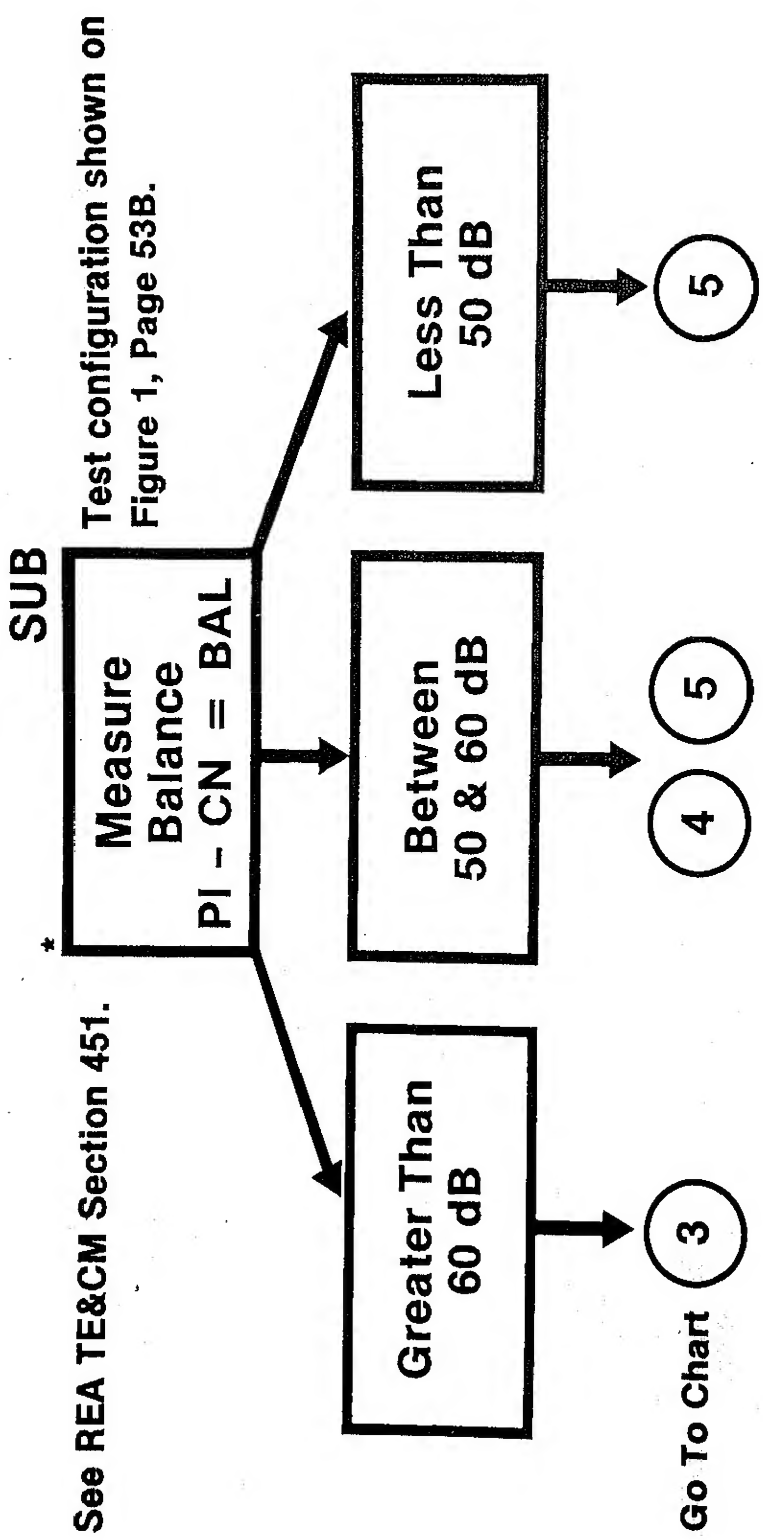
Gas Tubes: Inspect. Replace damaged or *defective tubes.

Carbon Blocks: Inspect. Clean or replace dirty blocks. Replace damaged or defective carbon blocks.

Station Fuses: Inspect for corrosion. Clean fuse holder contacts. Replace both fuses with units known to be good.

*Identification of defective requires use of a gas tube checker.

Chart *2



*Measurements may be completed with Loop Checking equipment.

TABLE I
INVERSE POWER SUMMATION

FIND DIFFERENCE, IN DBRNC, BETWEEN MEASUREMENT 1 & 3 (Nm) OF FIGURE 2 IN COLUMN A. ALGEBRAICALLY ADD THE VALUE FOUND IN COLUMN B FOR THIS DIFFERENCE TO RECORDED RESULTS OF MEASUREMENT 3 TO FIND NOISE DUE TO CONNECTOR BALANCE.

A	B	A	B	A	B	A	B	A	B
0.5	-9.1	3.5	0.9	6.5	5.4	9.5	9.0	12.5	12.2
1.0	-5.9	4.0	1.8	7.0	6.0	10.0	9.5	13.0	12.8
1.5	-3.8	4.5	2.6	7.5	6.6	10.5	10.1	13.5	13.3
2.0	-2.3	5.0	3.3	8.0	7.3	11.0	10.6	14.0	13.8
2.5	-1.1	5.5	4.1	8.5	7.8	11.5	11.2	14.5	14.3
3.0	0	6.0	4.7	9.0	8.4	12.0	11.7	15.0	14.9

NOTE: IF DIFFERENCE IS GREATER THAN 15DBRNC THE POSSIBILITY OF EQUIPMENT SATURATION SHOULD BE INVESTIGATED.

EXAMPLE 1

MEASUREMENT 1 (Nm) 15 DBRNC
MEASUREMENT 1 (NL) 30 DBRNC
MEASUREMENT 3 14.5 DBRNC

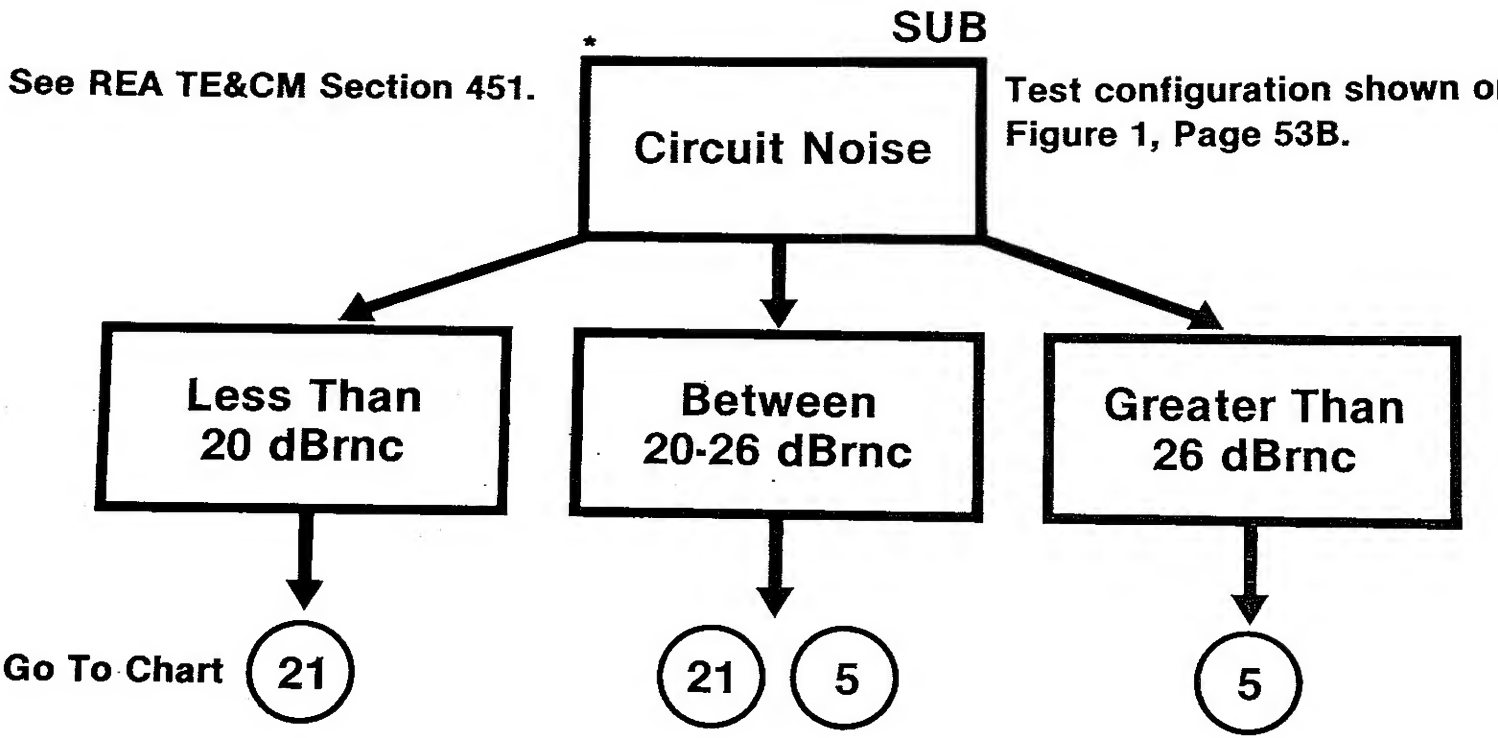
MEAS. 1 (Nm)	15.0	BAT 0.5	-9.1	
MEAS. 3	- 14.5	MEAS. 3	+14.5	
DIFF.	0.5	CONNECTOR NOISE	5.4	
MEAS. 1 (NL)	30.0	PWR. INFL.	70.0	
	+ 40.0	CONNECTOR NOISE	- 5.4	
PWR. INF.L.	70.0	CONNECTOR BALANCE	64.5 DB.	

EXAMPLE 2

MEASUREMENT 1 (Nm) 20 DBRNC
MEASUREMENT 1 (NL) 37 DBRNC
MEASUREMENT 3 7 DBRNC

MEAS. 1 (Nm)	20.0	BAT 13	12.8	
MEAS. 3	- 7.0	MEAS. 3	+ 7.0	
DIFF.	13.0	CONNECTOR NOISE	19.8	
MEAS. 1 (NL)	37.0	PWR. INF.	77.0	
	+40.0	CONNECTOR NOISE	-19.8	
PWR. INF.L.	77.0	CONNECTOR BALANCE	57.2 DB	

Chart *3



*Measurements may be completed with Loop Checking equipment.

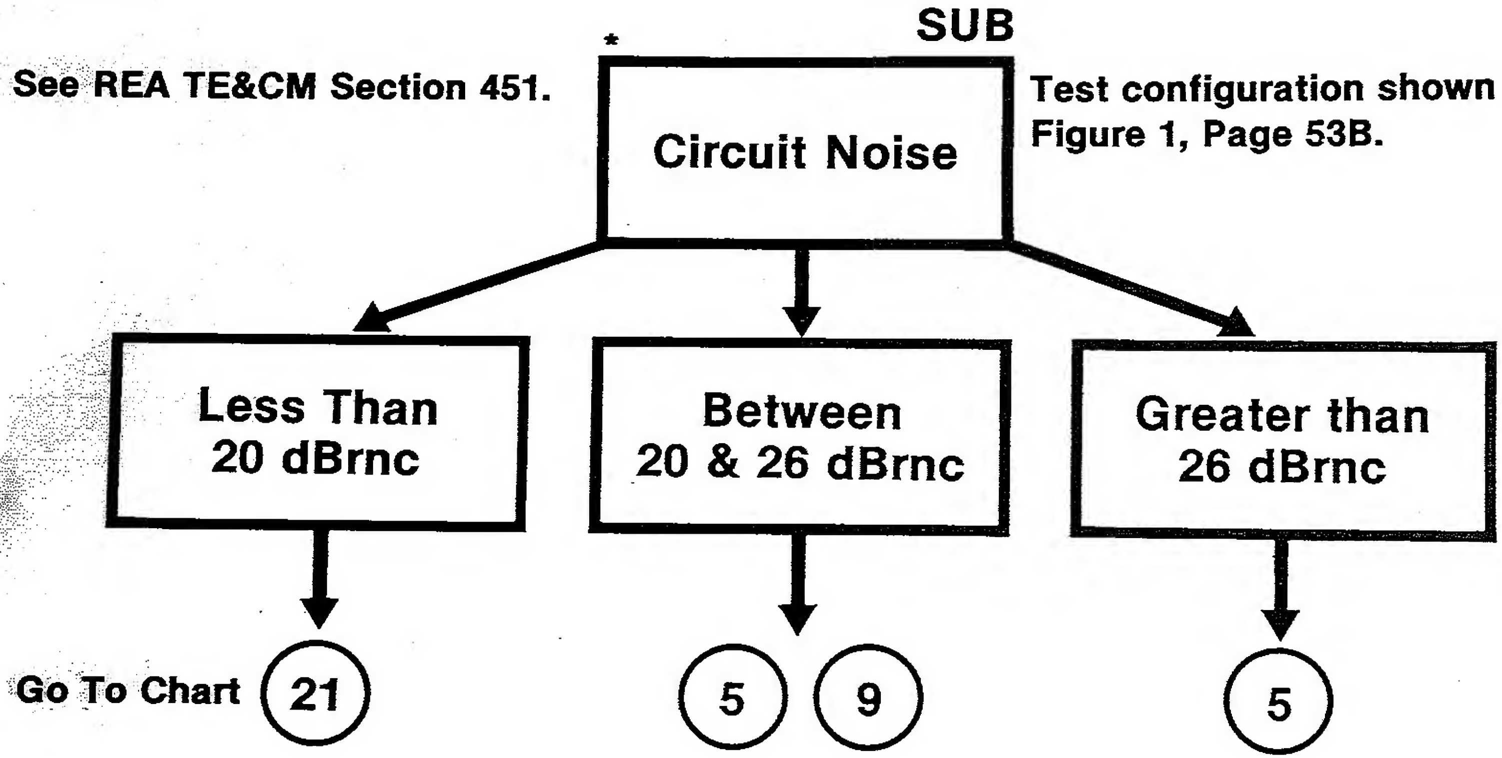
While at the central office don't forget to check ground connections.

1. Are they solid? Tighten if loose.
2. Is positive battery terminal connected directly to ground and isolated electrically from all other ground points?
   SXS Office - connected to MDF ground bar.
   Digital Office - connected to ground window points
3. Is there a direct connection between the main ground bar and the ground bar in the main ac power panel.
4. Refer to REA TE&CM Section 810 for further details.

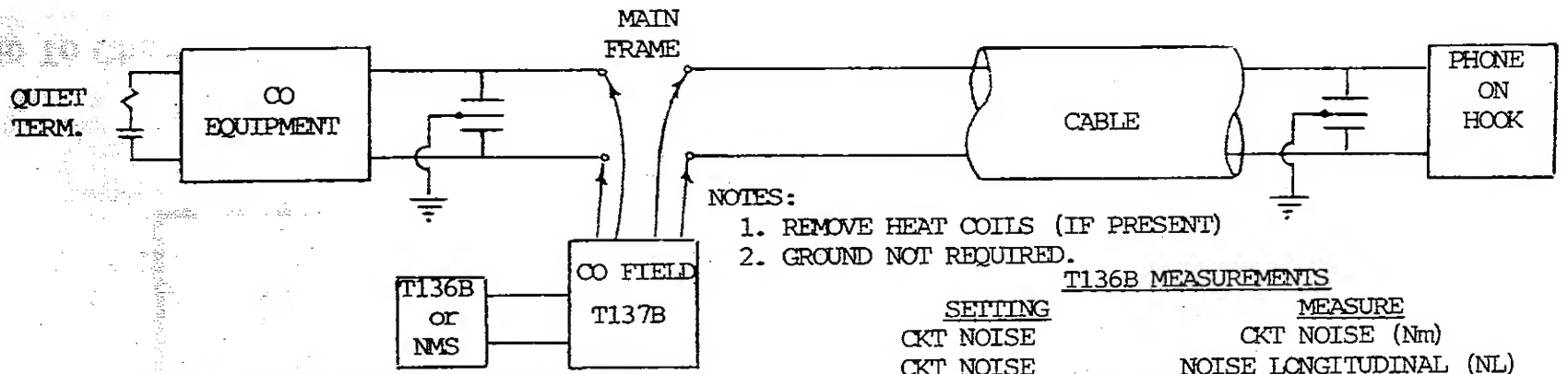
Chart *4

See REA TE&CM Section 451.

Test configuration shown on Figure 1, Page 53B.



*Measurements may be completed with Loop Checking equipment.



NOTES:
1. REMOVE HEAT COILS (IF PRESENT)
2. GROUND NOT REQUIRED.

T136B MEASUREMENTS

SETTING	MEASURE
CKT NOISE	CKT NOISE (Nm)
CKT NOISE	NOISE LONGITUDINAL (NL)
	CALCULATE BALANCE

NMS MEASUREMENTS

	SETTING	MEASURE
C-MSG	900 TERM MEAS	Nm(CKT NOISE)
C-MSG	900 TERM MEAS	NOISE LONGITUDINAL (NL)
		CALCULATE BALANCE

WILCOM T137B SWITCH POSITIONS

	MEAS. NO. 1	MEAS. NO. 2	MEAS. NO. 3
TERM:	OFF	OFF	OFF
LONG. CURRENT:	OFF FOR CKT. NOISE ON FOR NOISE LONG.	OFF FOR CKT. NOISE ON FOR NOISE LONG.	OFF FOR CCT NOISE
DIAL. MEAS:	MEAS.	MEAS.	MEAS.
FUNCTION:	POSITION 1.	POSITION 2	POSITION 4

$$\text{TRUE EQUIPMENT BALANCE} = (\text{NOISE LONG.}+40) - 10\log_{10}\left(\log_{10}^{-1}\left(\frac{\text{CKT NOISE (MEAS.1)}}{10}\right) - \log_{10}^{-1}\left(\frac{\text{CKT NOISE (MEAS.3)}}{10}\right)\right)$$

NOTE: THE INVERSE POWER SUMMATION CAN BE SOLVED WITH TABLE I. (PAGE 53F)

ISOLATION MEASUREMENT AT MDF
FIGURE 2

Chart *5

CO

*

See REA TE&CM Section 451.1.

Isolation Measurement at MDF

Test configuration shown on Figure 2, Page 53 J. See also the notes on Page 53H.

Problem in Central Office

Problem in Cable?

Go To Chart 6

Go To Chart 7

*Measurements may be completed with Loop Checking equipment.

TABLE II

For identification of an Open Shield (Based on 540 Hz)

Length-Kf.	24 GAUGE SHIELDS: 5mil CU, 8mil Al & 7mil 194															
	12 Pr.		18 Pr.		25 Pr.		50 Pr.		75 Pr.		100 Pr.		150 Pr.		200 Pr.	
	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.
1	0.8	0.2	0.8	0.1	0.8	0.1	0.8	0.1	0.8	0.1	0.7	0.1	0.7	–	0.7	–
2	1.8	0.6	1.8	0.5	1.8	0.5	1.7	0.4	1.7	0.3	1.6	0.2	1.6	0.2	1.6	0.1
3	2.6	1.1	2.5	1.0	2.5	0.9	2.5	0.7	2.4	0.5	2.4	0.4	2.3	0.3	2.3	0.3
4	3.2	1.5	3.1	1.3	3.1	1.2	3.0	0.9	3.0	0.8	2.9	0.6	2.9	0.5	2.8	0.4
5	3.6	1.9	3.6	1.7	3.6	1.5	3.5	1.2	3.4	1.0	3.4	0.8	3.3	0.6	3.2	0.5
6	4.0	2.2	4.0	2.0	3.9	1.8	3.8	1.4	3.8	1.2	3.7	1.0	3.6	0.8	3.6	0.6
7	4.3	2.4	4.2	2.2	4.2	2.0	4.1	1.6	4.0	1.3	4.0	1.1	3.9	0.9	3.8	0.7
8	4.5	2.6	4.5	2.4	4.4	2.2	4.3	1.8	4.3	1.5	4.2	1.3	4.1	1.0	4.1	0.8
9	4.7	2.8	4.7	2.6	4.6	2.4	4.5	1.9	4.5	1.6	4.4	1.4	4.3	1.1	4.2	0.9
10	4.9	3.0	4.8	2.7	4.8	2.5	4.7	2.0	4.60	1.7	4.6	1.5	4.5	1.2	4.4	1.0

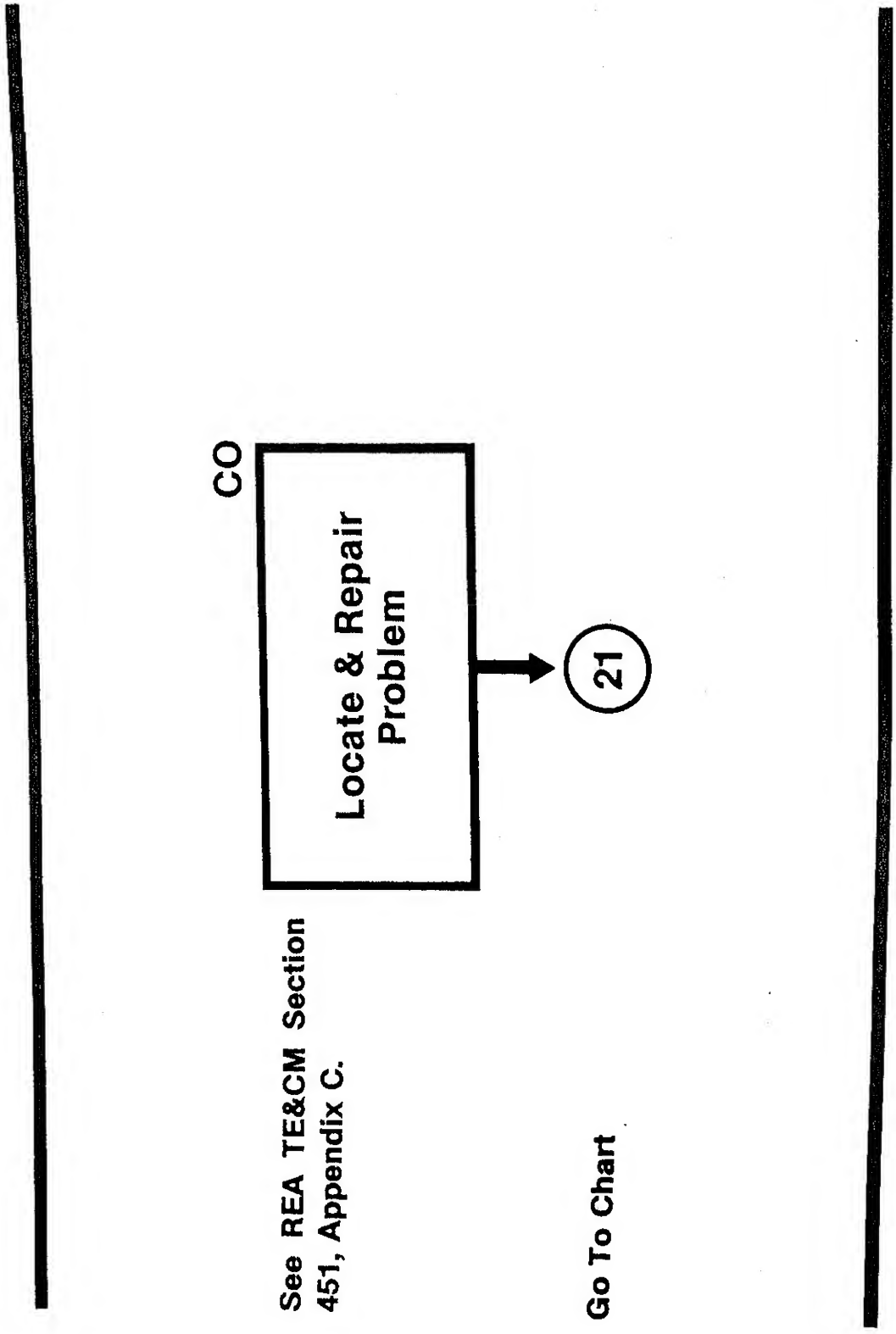
1. If measured difference is nearly equal to (less than 50% greater) or less than the calculated difference, the shield can be considered acceptable.

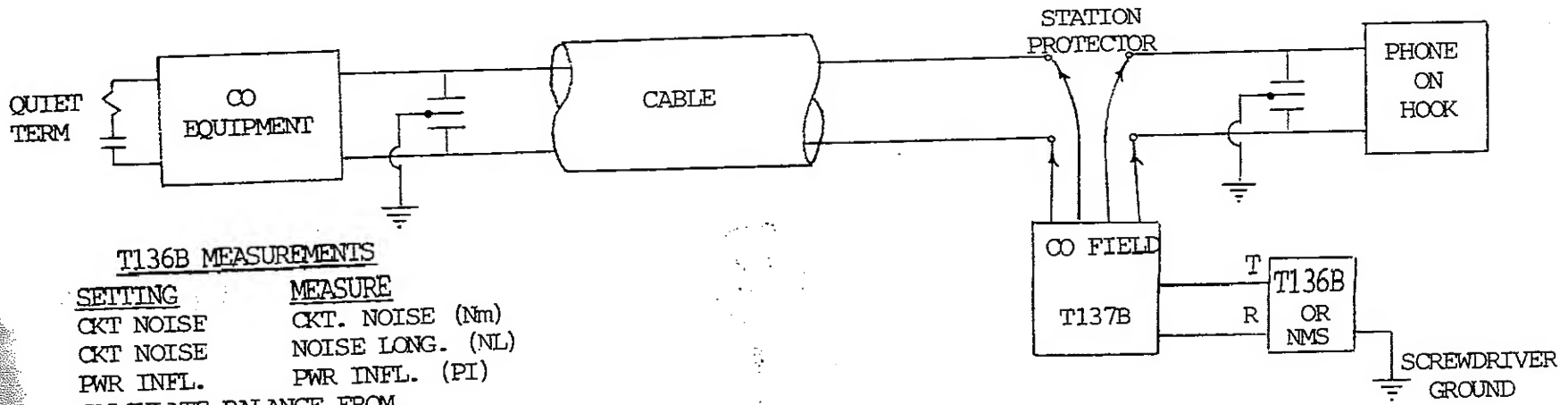
2. If measured difference is more than 50% greater than the calculated difference the shield is probably partially open.

3. If measured difference is nearly equal to or greater than the value in the "10 Pr." column, the shield can be considered completely open.

NOTE: Use for Air Core, Filled, and Foam Insulated Filled Cables.

Chart 6


CO
Locate & Repair Problem
21
See REA TE&CM Section 451, Appendix C.
Go To Chart



T136B MEASUREMENTS

SETTING	MEASURE
CKT NOISE	CKT. NOISE (Nm)
CKT NOISE	NOISE LONG. (NL)
PWR INFL.	PWR INFL. (PI)

CALCULATE BALANCE FROM HIGHEST PI OR (NL + 40)

NMS MEASUREMENTS

SETTINGS		MEASURE
CMSG	900 TERM MEAS.	Nm (CKT NOISE)
CMSG	900 TERM MEAS.	NOISE LONG. (NL)
CMSG	Ng MEAS.	Ng (NOISE-TO-GROUND

CALCULATE BALANCE FROM HIGHEST PI: (NL + 40) OR (Ng + 40)

*NOTE: MEASURE ONLY WHEN HIGH CKT NOISE IS FOUND ON MEAS. NO. 2.

T137B SETTINGS

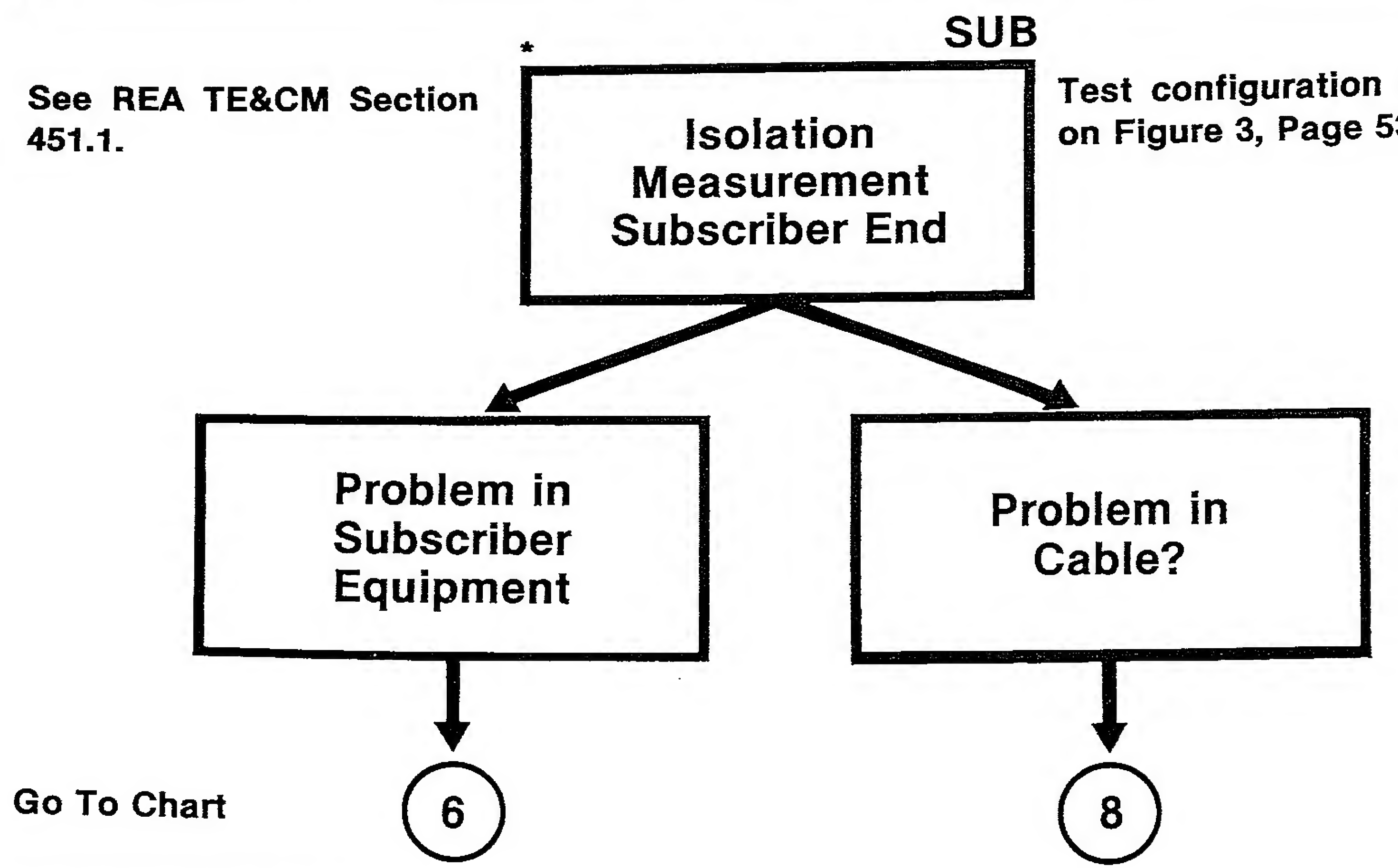
	MEAS. NO. 1	MEAS. NO. 2	*MEAS. NO. 3
TERM:	OFF	OFF	OFF
LONG CURRENT:	OFF FOR CKT NOISE ON FOR NOISE LONG.	OFF FOR CKT NOISE ON FOR NOISE LONG.	OFF FOR CKT NOISE
DIAL-MEAS: FUNCTION:	MEAS. POSITION 1	MEAS. POSITION 2	MEAS. POSITION 6

ISOLATION MEASUREMENT AT SUBSCRIBER END
FIGURE 3

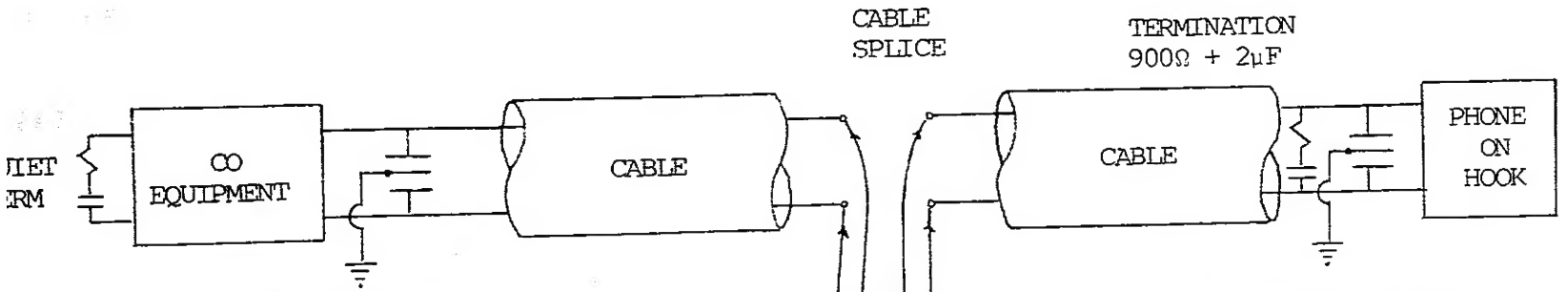
Chart *7

See REA TE&CM Section 451.1.

Test configuration shown on Figure 3, Page 53N.



*Measurements may be completed with Loop Checking equipment.



NMS MEASUREMENTS

	SETTINGS	MEASURE
CMSG	900 TERM MEAS.	Nm(CKT NOISE)
CMSG	900 TERM MEAS.	NOISE LONG. (NL)
CMSG	Ng MEAS.	Ng (NOISE-TO-GROUND)

CALCULATE BALANCE FROM HIGHEST PI:
(NL + 40) OR (Ng + 40).

T136B MEASUREMENTS

SETTINGS	MEASURE
CKT NOISE	CKT NOISE (Nm)
CKT NOISE	NOISE LONG. (NL)
PWR. INFL.	PWR. INFL. (PI)

CALCULATE BALANCE FROM
HIGHEST PI OR (NL + 40)

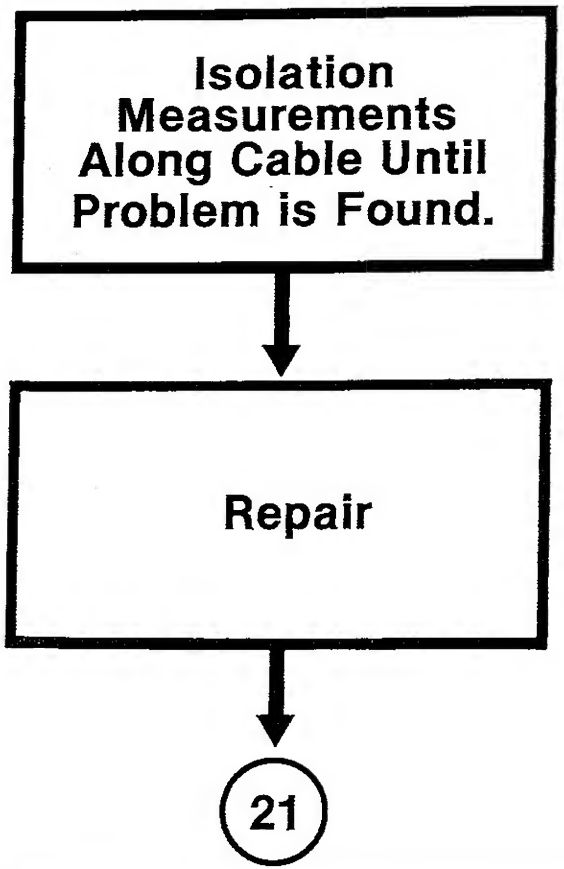
T137B SETTINGS

	MEAS. NO. 1	MEAS. NO. 2.
TERM:	OFF	OFF
LONG. CURRENT:	OFF FOR CKT NOISE ON FOR NOISE LONG.	OFF FOR CKT NOISE ON FOR NOISE LONG.
DIAL-MEAS: FUNCTION:	MEAS. POSITION 1	MEAS. POSITION 2

ISOLATION MEASUREMENT ALONG CABLE
FIGURE 4

Chart *8

See REA TE&CM Section 451.1.

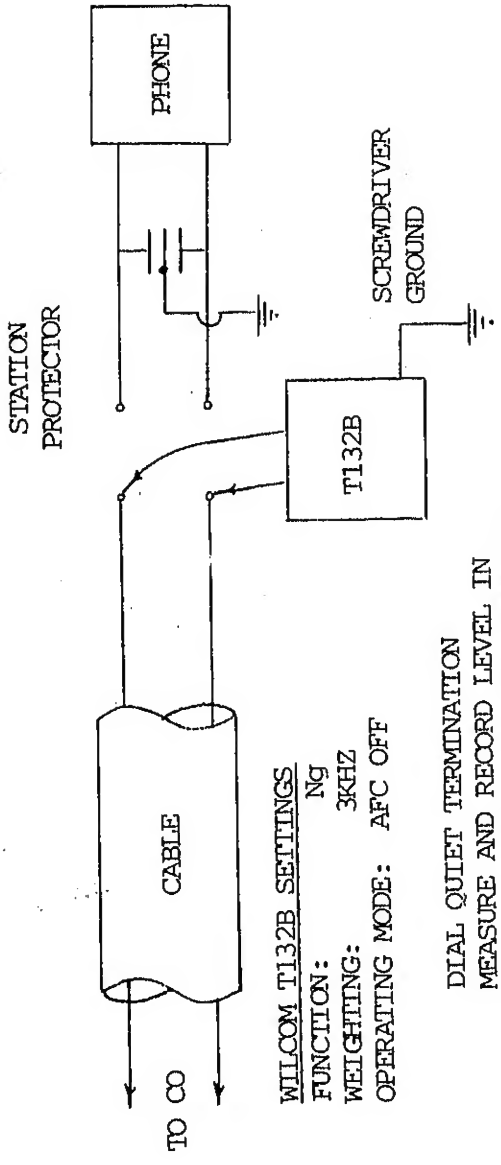


Test configuration shown on Figure 4, Page 53 P.

See REA TE&CM Section 451.8.

Go To Chart

*Measurements may be completed with Loop Checking equipment.



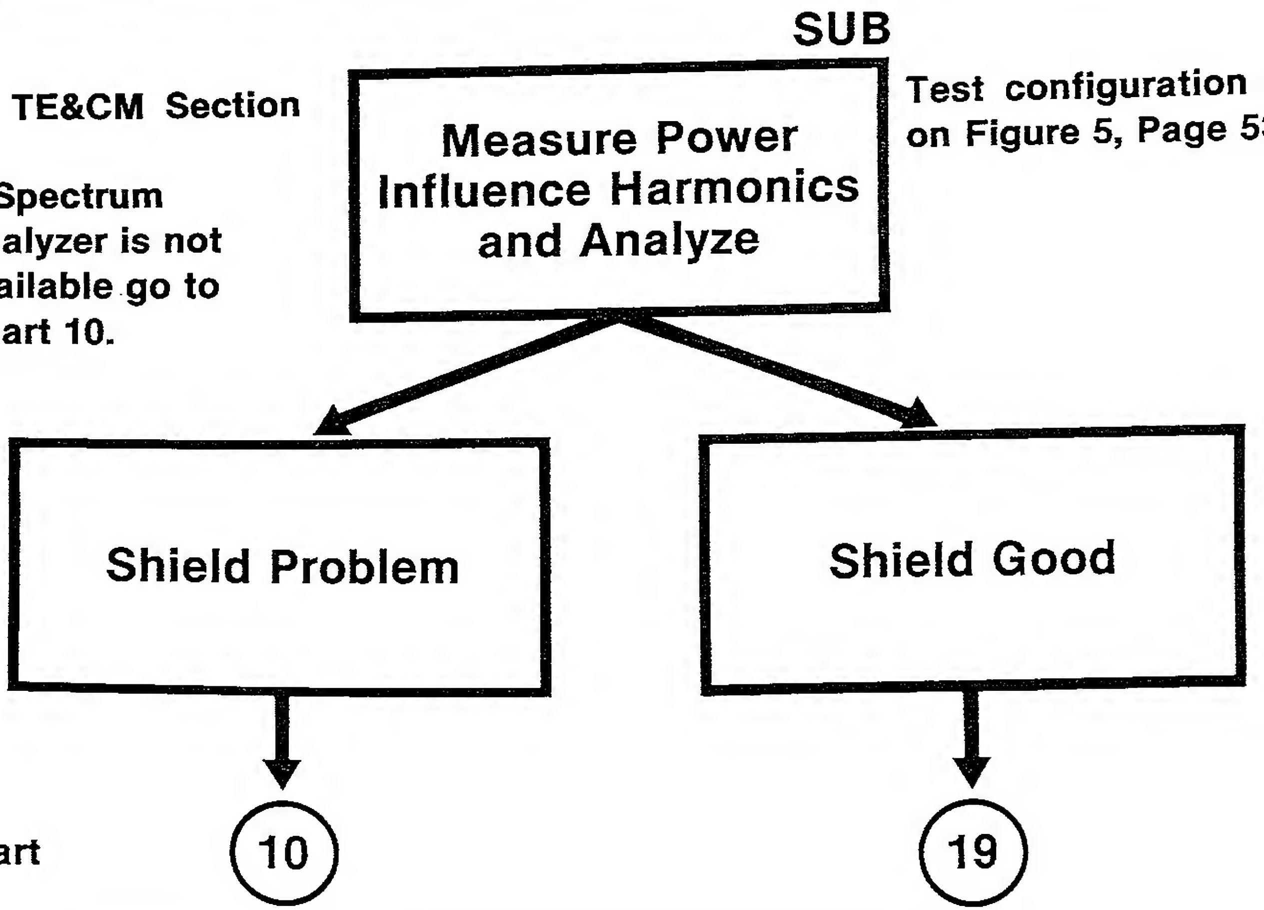
HARMONIC ANALYSIS OF POWER INFLUENCE
FIGURE 5

Chart 9

See REA TE&CM Section 452.1.

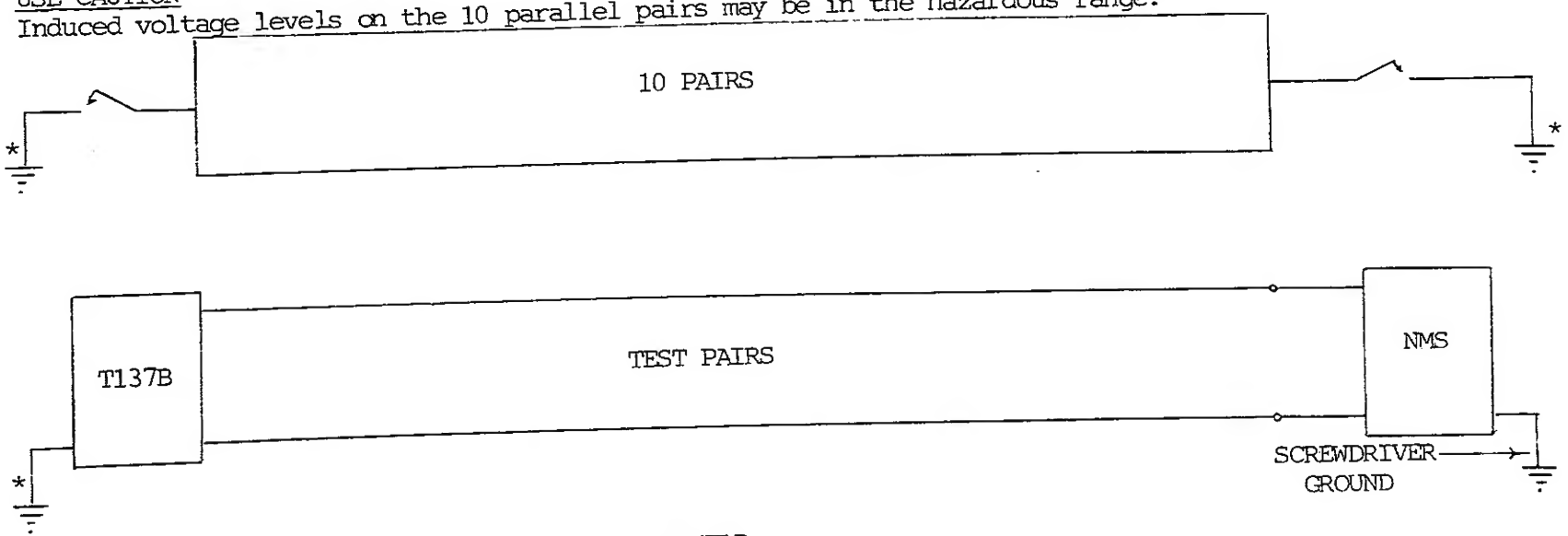
NOTE: If Spectrum Analyzer is not available go to Chart 10.

Test configuration shown on Figure 5, Page 53R.



Go To Chart

USE CAUTION
Induced voltage levels on the 10 parallel pairs may be in the hazardous range.



1. MEASURE Ng WITH 10-PAIRS UNGROUNDED.
2. MEASURE Ng WITH 10-PAIRS GROUNDED.
3. CALCULATE MEASURED DIFFERENCE - MEAS. 1 MINUS MEAS. 2.
4. DETERMINE SHIELD QUALITY FROM APPROPRIATE TABLE:

	5 mil CU 8 mil Al, 7 mil 194	10 mil CU	6 mil CCS, 6 mil 194
24 GA.	TABLE II, PAGE 53L	TABLE V, PAGE 54I	TABLE VIII, PAGE 540
22 GA.	TABLE III, PAGE 54C	TABLE VI, PAGE 54K	TABLE IX, PAGE 54Q
19 GA.	TABLE IV, PAGE 54E	TABLE VII, PAGE 54M	TABLE X, PAGE 54S

CU-COPPER AL-ALUMINUM CCS-COPPER CLAD STELL 194-ALLOY 194

* GROUNDS TO MGN.

T137B SETTINGS
TERM: ON
LONG. CURRENT: OFF
DIAL-MEAS: MEAS.
FUNCTION: POSITION 5
CONNECT TEST PAIR TO FIELD TERMINALS.

NMS MEASUREMENTS SETTINGS MEASURE
C-MSG Ng MEAS. Ng

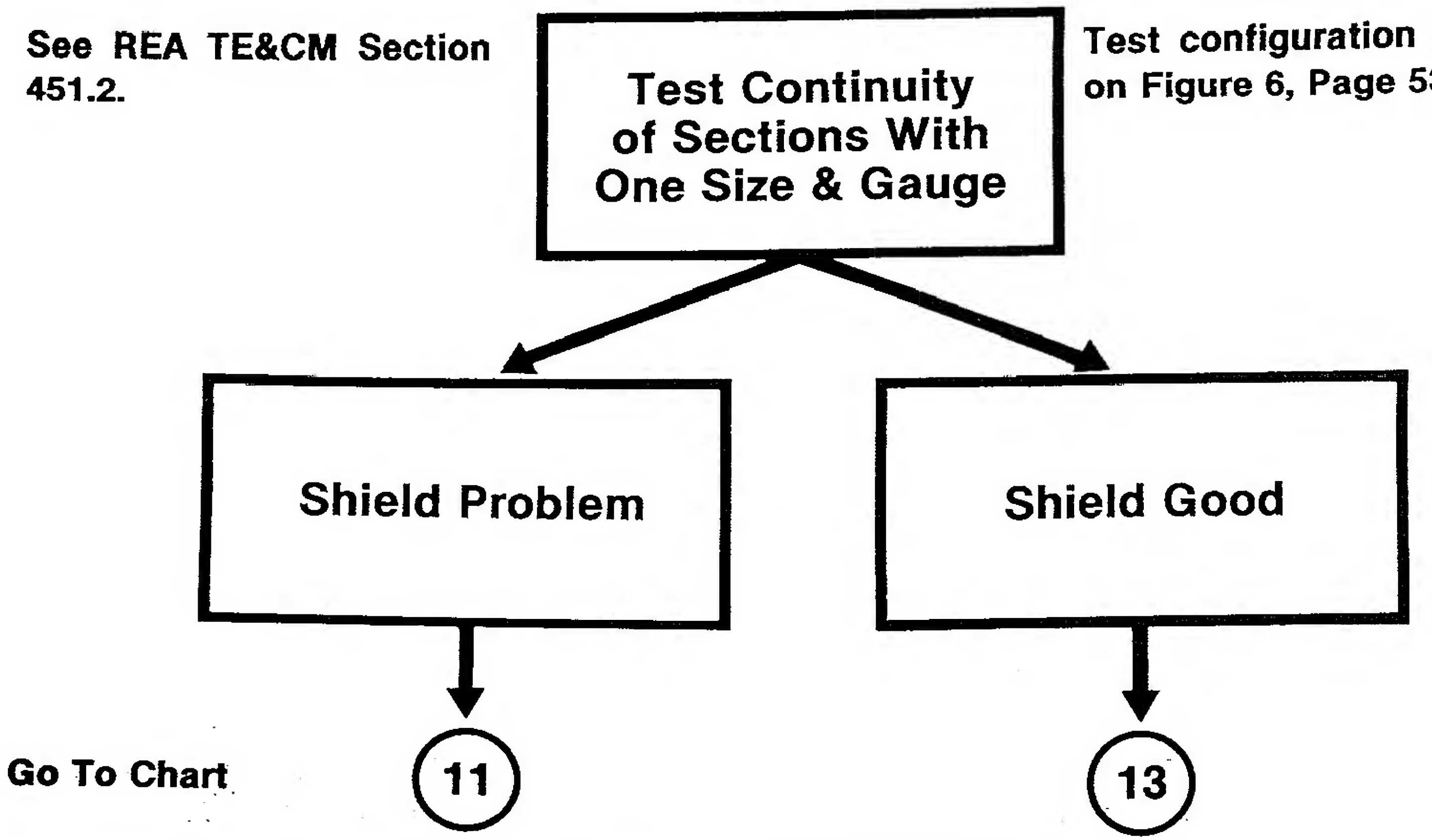
SHIELD MATERIALS
CU Copper
AL Aluminum
CCS Copper Clad Steel
194 Alloy 194

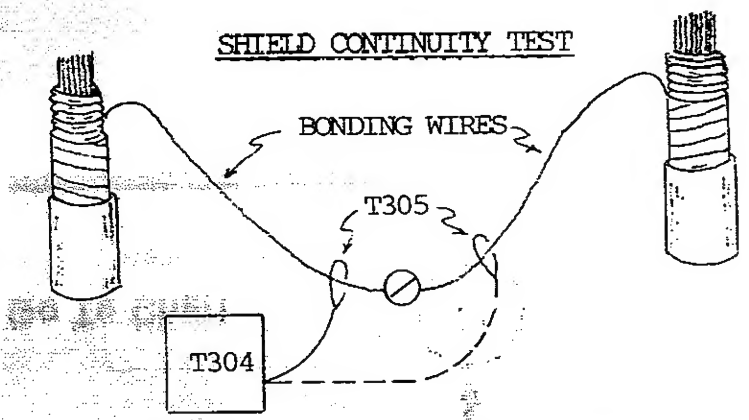
SHIELD CONTINUITY TEST
FIGURE 6

Chart 10

See REA TE&CM Section 451.2.

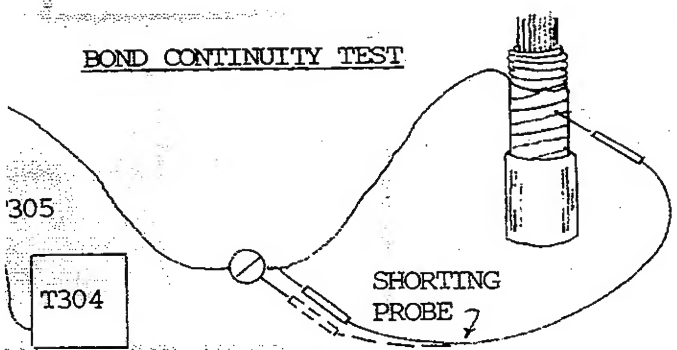
Test configuration shown on Figure 6, Page 53T.





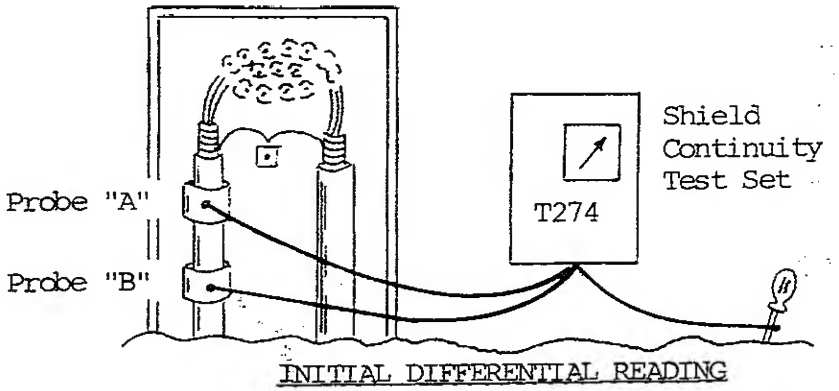
1. READ & RECORD CURRENT IN EACH BONDING WIRE AT EACH SPLICE.
2. CURRENT WILL REDUCE TO NEAR ZERO IN VICINITY OF OPEN SHIELD.
3. SEE REA TE&CM 451.2 FOR COMPLETE DETAILS.

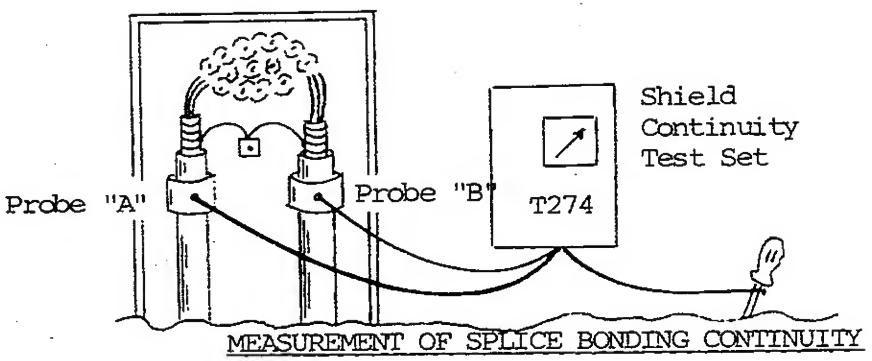
FIGURE 7A



) CURRENT WITHOUT SHORTING PROBE
) CURRENT WITH BOND WIRE BYPASSED BY PROBE
? IS 1.06 TIMES OR MORE GREATER THAN 1 BOND IS
ECTIVE

FIGURE 7B

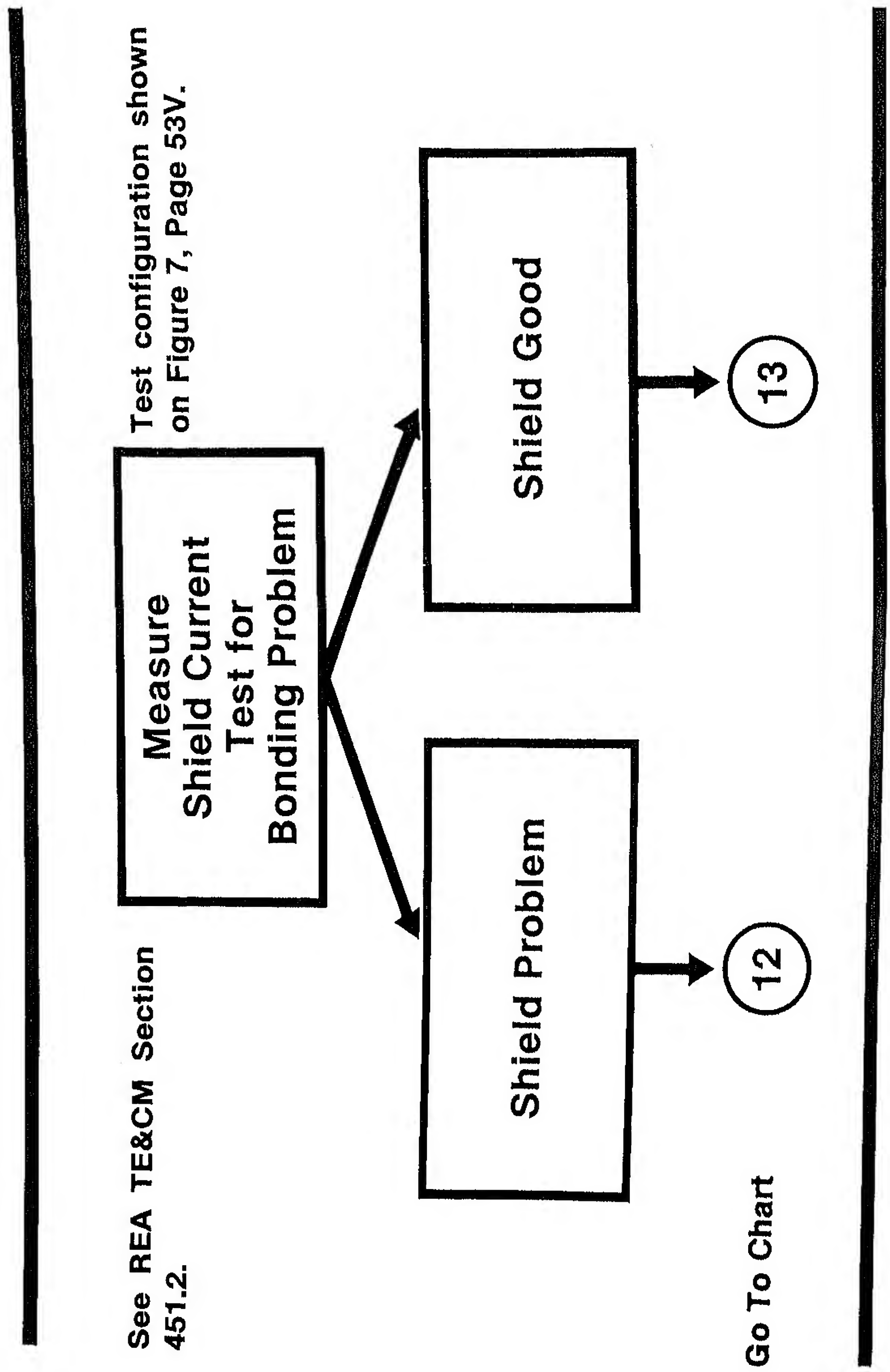


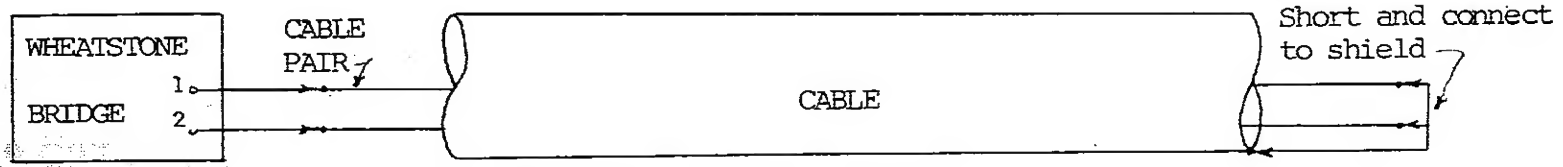


1. IF MEASUREMENT IS MORE THAN 2 DB GREATER THAN DIFFERENTIAL READING, BOND IS DEFECTIVE.
2. SEE REA TE&CM 451.2 FOR COMPLETE DETAILS.

SHIELD SPLICE CONTINUITY TEST
FIGURE 7C

Chart 11


Test configuration shown on Figure 7, Page 53V.
Measure Shield Current Test for Bonding Problem
Shield Good
13
Shield Problem
12
See REA TE&CM Section 451.2.
Go To Chart



1. Measure loop resistance R_1.

2. Measure loop resistance R_2.
3. Calculate shield resistance.

$$\text{Shield Resistance} = R_2 - \frac{R_1}{4}$$

WHEATSTONE BRIDGE MEASUREMENT OF SHIELD CONTINUITY
FIGURE 8

Chart 12

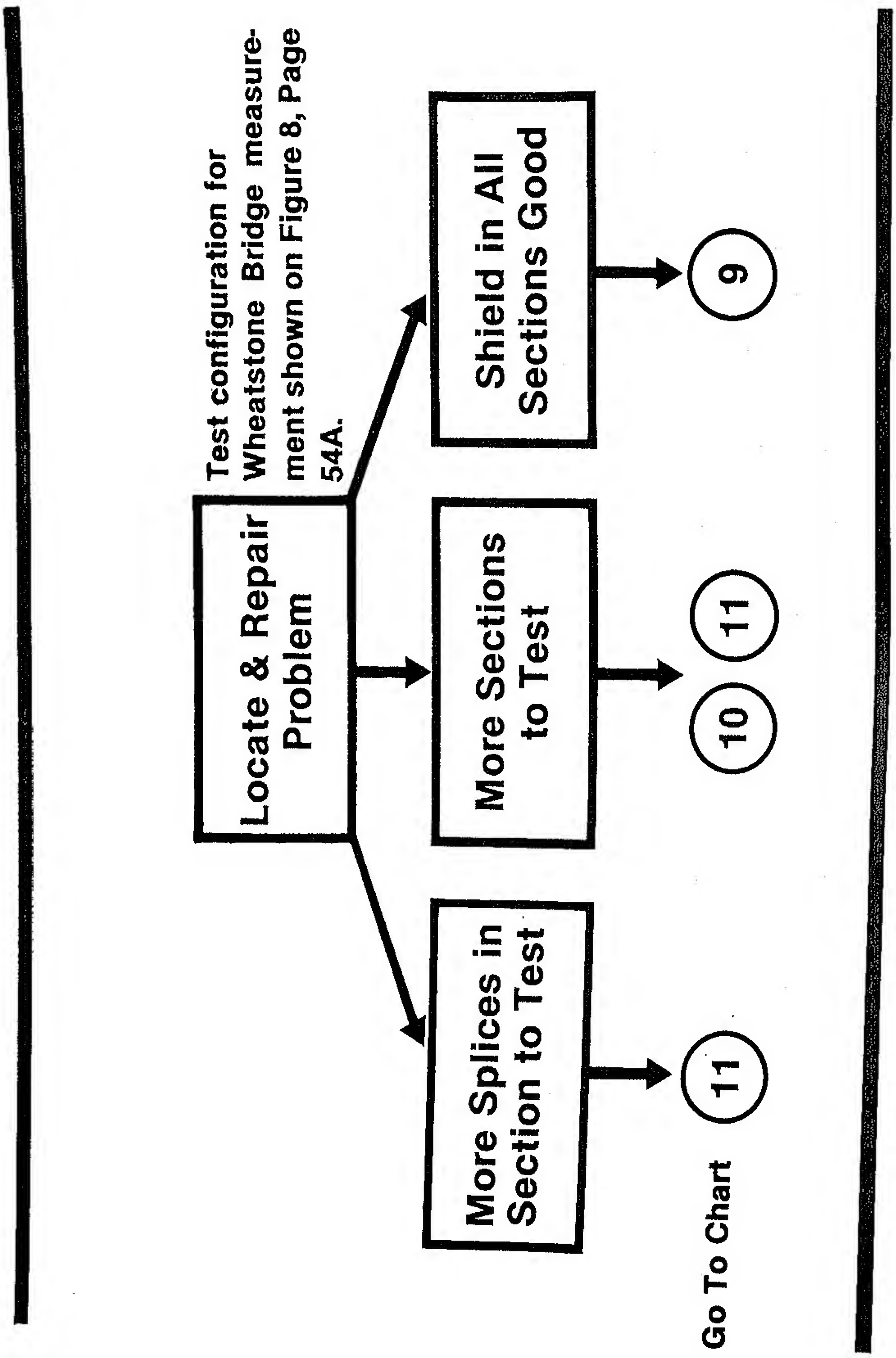

Locate & Repair Problem
Test configuration for Wheatstone Bridge measurement shown on Figure 8, Page 54A.
More Splices in Section to Test
More Sections to Test
Shield in All Sections Good
Go To Chart
11
10
11
9

TABLE III

For identification of an Open Shield (Based on 540 Hz)

Length-Kf.	22 GAUGE SHIELDS: 5mil CU, 8mil Al & 7mil 194															
	12 Pr.		18 Pr.		25 Pr.		50 Pr.		75 Pr.		100 Pr.		150 Pr.		200 Pr.	
	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.
1	0.9	0.2	0.9	0.1	0.9	0.1	0.9	0.1	0.8	0.1	0.8	0.1	0.8	–	0.8	–
2	2.2	0.7	2.1	0.6	2.1	0.5	2.0	0.4	2.0	0.3	2.0	0.2	1.9	0.2	1.9	0.1
3	3.3	1.2	3.2	1.1	3.2	1.0	3.1	0.7	3.0	0.5	3.0	0.5	2.9	0.3	2.9	0.3
4	4.1	1.8	4.1	1.5	4.0	1.4	3.9	1.0	3.8	0.8	3.8	0.7	3.7	0.5	3.6	0.4
5	4.8	2.2	4.7	1.9	4.7	1.7	4.6	1.3	4.5	1.0	4.4	0.9	4.3	0.7	4.3	0.6
6	5.4	2.6	5.3	2.3	5.2	2.1	5.1	1.6	5.0	1.2	5.0	1.1	4.9	0.8	4.8	0.7
7	5.8	2.9	5.7	2.6	5	2.3	5.6	1.8	5.4	1.4	5.4	1.3	5.3	1.0	5.2	0.8
8	6.2	3.2	6.1	2.8	6	2.6	5.9	2.0	5.8	1.6	5.8	1.4	5.6	1.1	5.6	0.9
9	6.5	3.4	6.4	3.1	6	2.8	6.2	2.2	6.1	1.7	6.1	1.6	5.9	1.2	5.9	1.0
10	6.8	3.7	6.7	3.3	6	3.0	6.5	2.3	6.4	1.9	6.3	1.7	6.2	1.3	6.1	1.1

1. If measured difference is ı r equal to (less than 50% greater) or less than the calculated difference, the shield can nsidered acceptable.

2. If measured difference is ı han 50% greater than the calculated difference the shield is probably partially open.

3. If measured difference is ı r equal to or greater than the value in the "10 Pr." column, the shield can be considered c ely open.

NOTE: Use for Air Core, Fille l Foam Insulated Filled Cables.

Chart 13

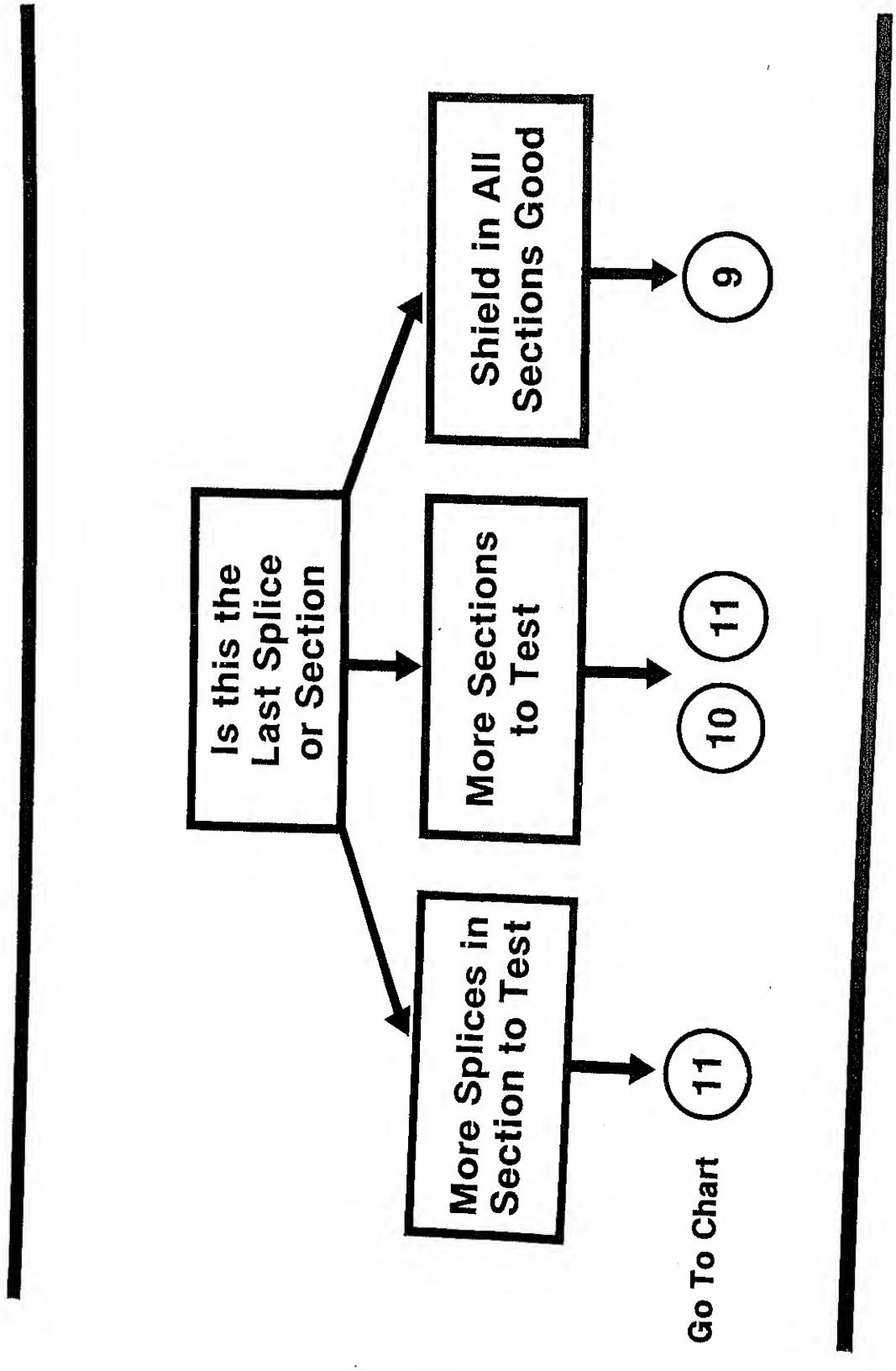

Is this the Last Splice or Section
Shield in All Sections Good
9
More Sections to Test
10
11
More Splices in Section to Test
Go To Chart
11

TABLE IV

For identification of an Open Shield (Based on 540 Hz)

Length-Kf.	19 GAUGE SHIELDS: 5mil CU, 8mil Al & 7mil 194															
	12 Pr.		18 Pr.		25 Pr.		50 Pr.		75 Pr.		100 Pr.		150 Pr.		200 Pr.	
	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.
1	1.0	0.2	1.0	0.1	1.0	0.1	0.9	0.1	0.9	0.1	0.9	-	0.9	-	0.9	-
2	2.5	0.7	2.5	0.6	2.5	0.5	2.4	0.3	2.3	0.3	2.3	0.2	2.2	0.2	2.2	0.1
3	4.0	1.3	3.9	1.1	3.9	1.0	3.7	0.6	3.7	0.5	3.6	0.5	3.5	0.3	3.5	0.3
4	5.2	1.9	5.1	1.7	5.1	1.4	4.9	1.0	4.8	0.8	4.8	0.7	4.7	0.5	4.6	0.4
5	6.2	2.5	6.1	2.1	6.1	1.9	5.9	1.3	5.8	1.1	5.7	0.9	5.6	0.7	5.6	0.6
6	7.0	2.9	6.9	2.5	6.9	2.2	6.7	1.5	6.6	1.3	6.5	1.1	6.4	0.8	6.3	0.7
7	7.7	3.4	7.6	2.9	7.6	2.6	7.3	1.8	7.3	1.5	7.2	1.3	7.1	1.0	7.0	0.9
8	8.3	3.7	8.2	3.2	8.1	2.9	7.9	2.0	7.8	1.7	7.8	1.5	7.6	1.1	7.6	1.0
9	8.8	4.0	8.7	3.5	8.7	3.1	8.4	2.2	8.3	1.9	8.3	1.6	8.1	1.2	8.1	1.0
10	9.3	4.3	9.2	3.8	9.1	3.4	8.9	2.4	8.8	2.0	8.7	1.8	8.5	1.4	8.5	1.2

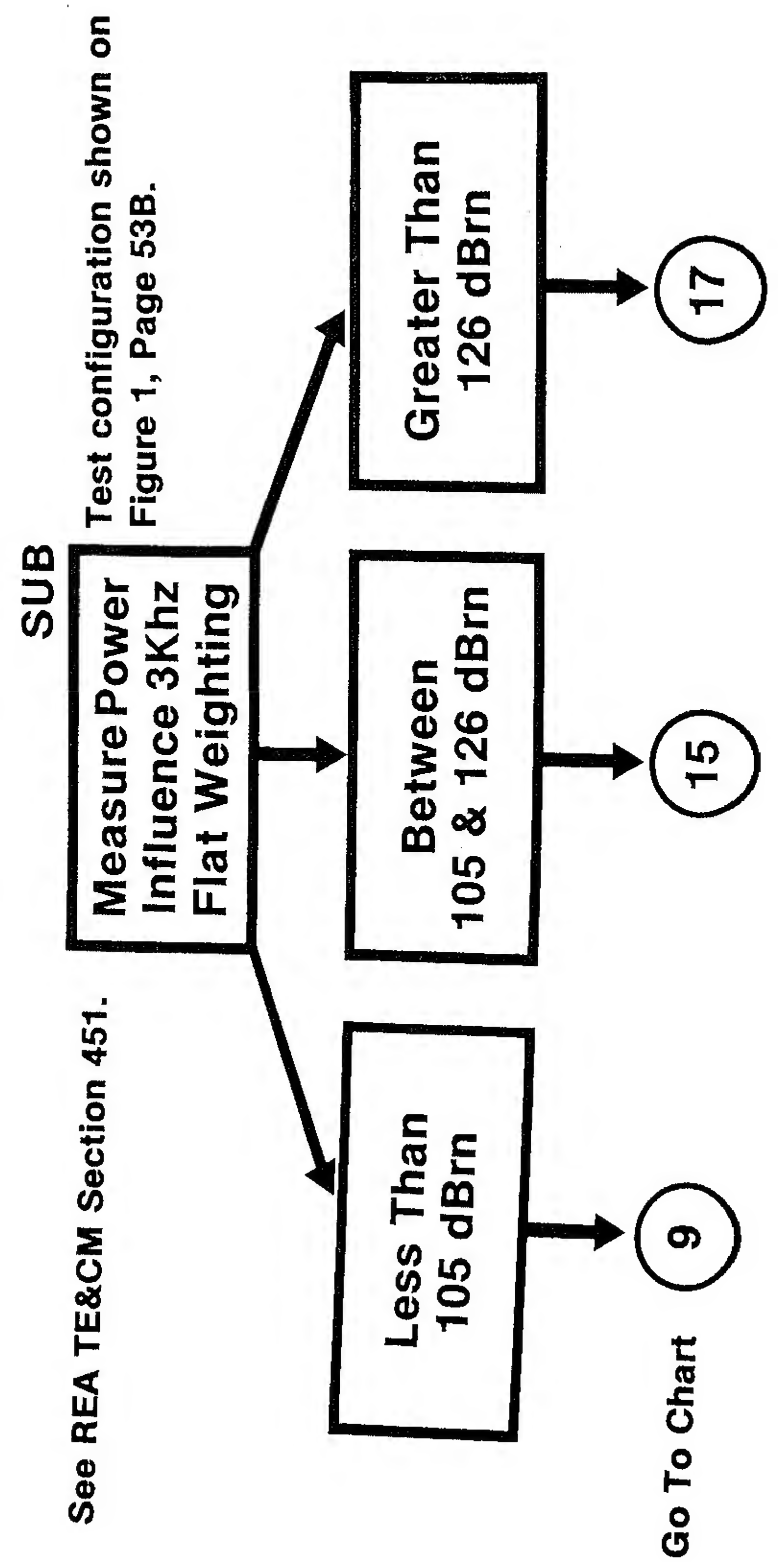
1. If measured difference is nearly equal to (less than 50% greater) or less than the calculated difference, the shield can be considered acceptable.

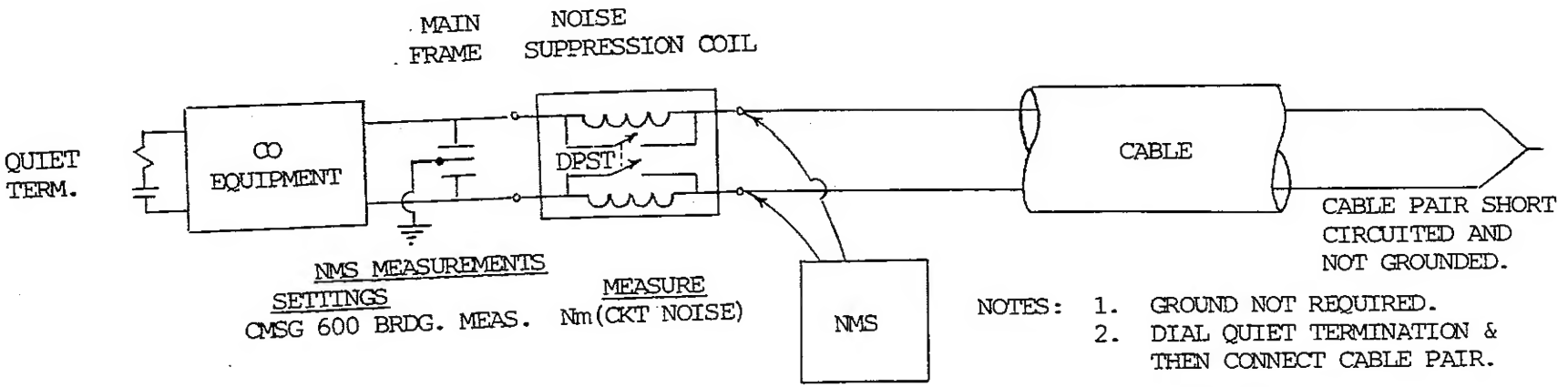
2. If measured difference is more than 50% greater than the calculated difference the shield is probably partially open.

3. If measured difference is nearly equal to or greater than the value in the "10 Pr." column, the shield can be considered completely open.

NOTE: Use for Air Core, Filled, and Foam Insulated Filled Cables.

Chart 14


See REA TE&CM Section 451.
SUB
Measure Power Influence 3Khz Flat Weighting
Test configuration shown on Figure 1, Page 53B.
Less Than 105 dBrn
Between 105 & 126 dBrn
Greater Than 126 dBrn
Go To Chart
9
15
17



1. MEASURE CKT NOISE WITH COIL REMOVED FROM CKT. (SWITCH CLOSED)
2. MEASURE CKT NOISE WITH COIL IN CKT. (SWITCH OPEN)
3. LARGE REDUCTION OF CKT NOISE (GREATER THAN 15 DBRNC) INDICATES PROBABLE SATURATION.

SATURATION TEST
FIGURE 9

Chart 15

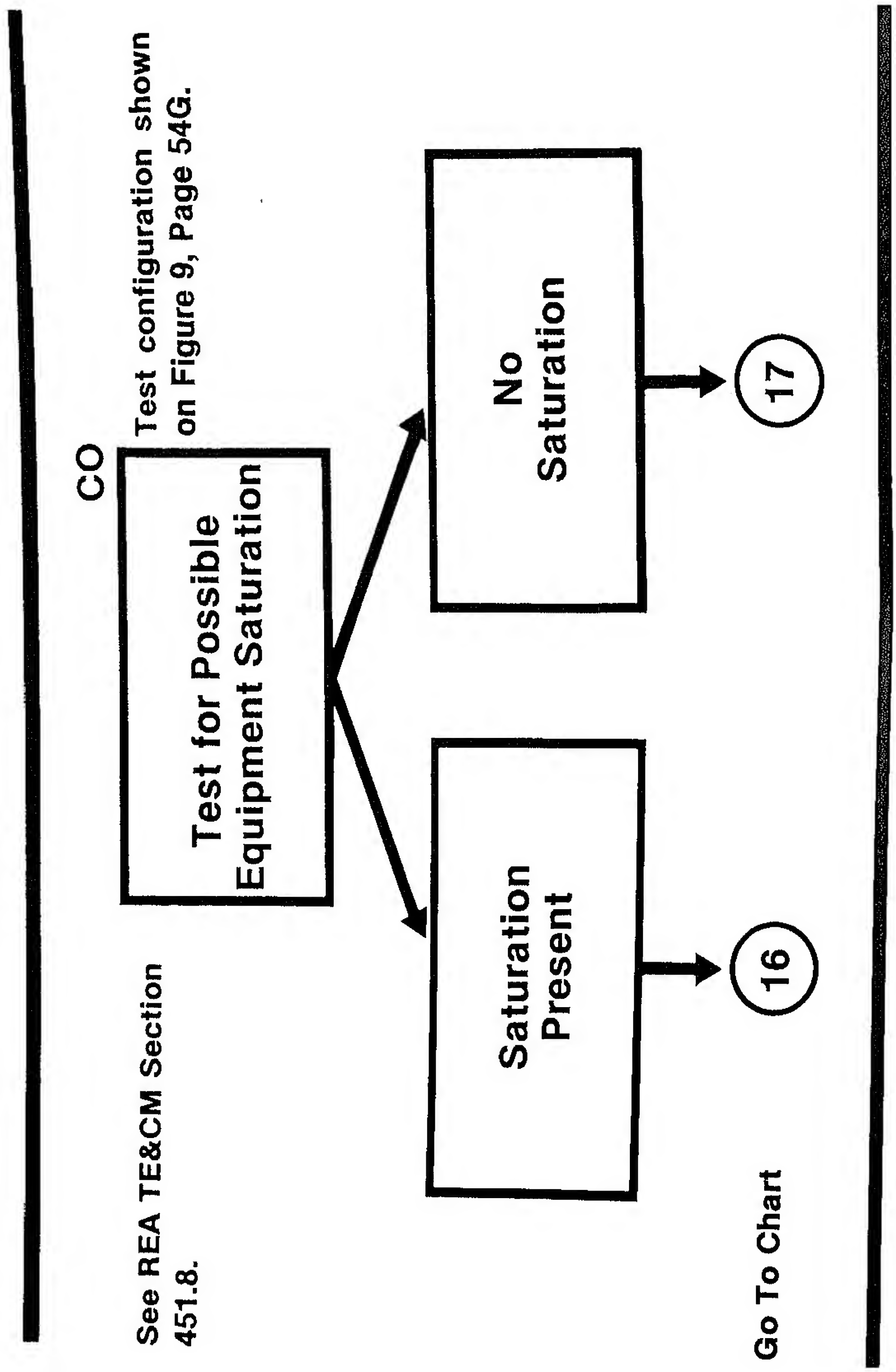

CO
Test configuration shown on Figure 9, Page 54G.
Test for Possible Equipment Saturation
No Saturation
Saturation Present
17
16
See REA TE&CM Section 451.8.
Go To Chart

TABLE V

For identification of an Open Shield (Based on 540 Hz)

Length-Kf.	24 GAUGE SHIELDS: 10mil CU															
	12 Pr.		18 Pr.		25 Pr.		50 Pr.		75 Pr.		100 Pr.		150 Pr.		200 Pr.	
	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.
1	0.8	0.1	0.8	0.1	0.8	0.1	0.8	–	0.7	–	0.7	–	0.7	–	0.7	–
2	1.8	0.3	1.8	0.3	1.8	0.2	1.7	0.2	1.7	0.1	1.6	0.1	1.6	0.1	1.6	0.1
3	2.6	0.6	2.5	0.5	2.5	0.4	2.5	0.3	2.4	0.2	2.4	0.2	2.3	0.1	2.3	0.1
4	3.2	0.8	3.1	0.7	3.1	0.6	3.0	0.4	3.0	0.3	2.9	0.3	2.9	0.2	2.8	0.2
5	3.6	1.0	3.6	0.9	3.6	0.8	3.5	0.6	3.4	0.4	3.4	0.4	3.3	0.3	3.2	0.2
6	4.0	1.2	4.0	1.1	3.9	1.0	3.8	0.7	3.8	0.5	3.7	0.5	3.6	0.3	3.6	0.3
7	4.3	1.4	4.2	1.2	4.2	1.1	4.1	0.8	4.0	0.6	4.0	0.5	3.9	0.4	3.8	0.3
8	4.5	1.5	4.5	1.4	4.4	1.2	4.3	0.9	4.3	0.7	4.2	0.6	4.1	0.4	4.1	0.4
9	4.7	1.7	4.7	1.5	4.6	1.3	4.5	1.0	4.5	0.8	4.4	0.7	4.3	0.5	4.2	0.4
10	4.9	1.8	4.8	1.6	4.8	1.4	4.7	1.1	4.6	0.8	4.6	0.7	4.5	0.5	4.4	0.4

1. If measured difference is nearly equal to (less than 50% greater) or less than the calculated difference, the shield can be considered acceptable.

2. If measured difference is more than 50% greater than the calculated difference the shield is probably partially open.

3. If measured difference is nearly equal to or greater than the value in the "10 Pr." column, the shield can be considered completely open.

NOTE: Use for Air Core, Filled, and Foam Insulated Filled Cables.

Chart 16

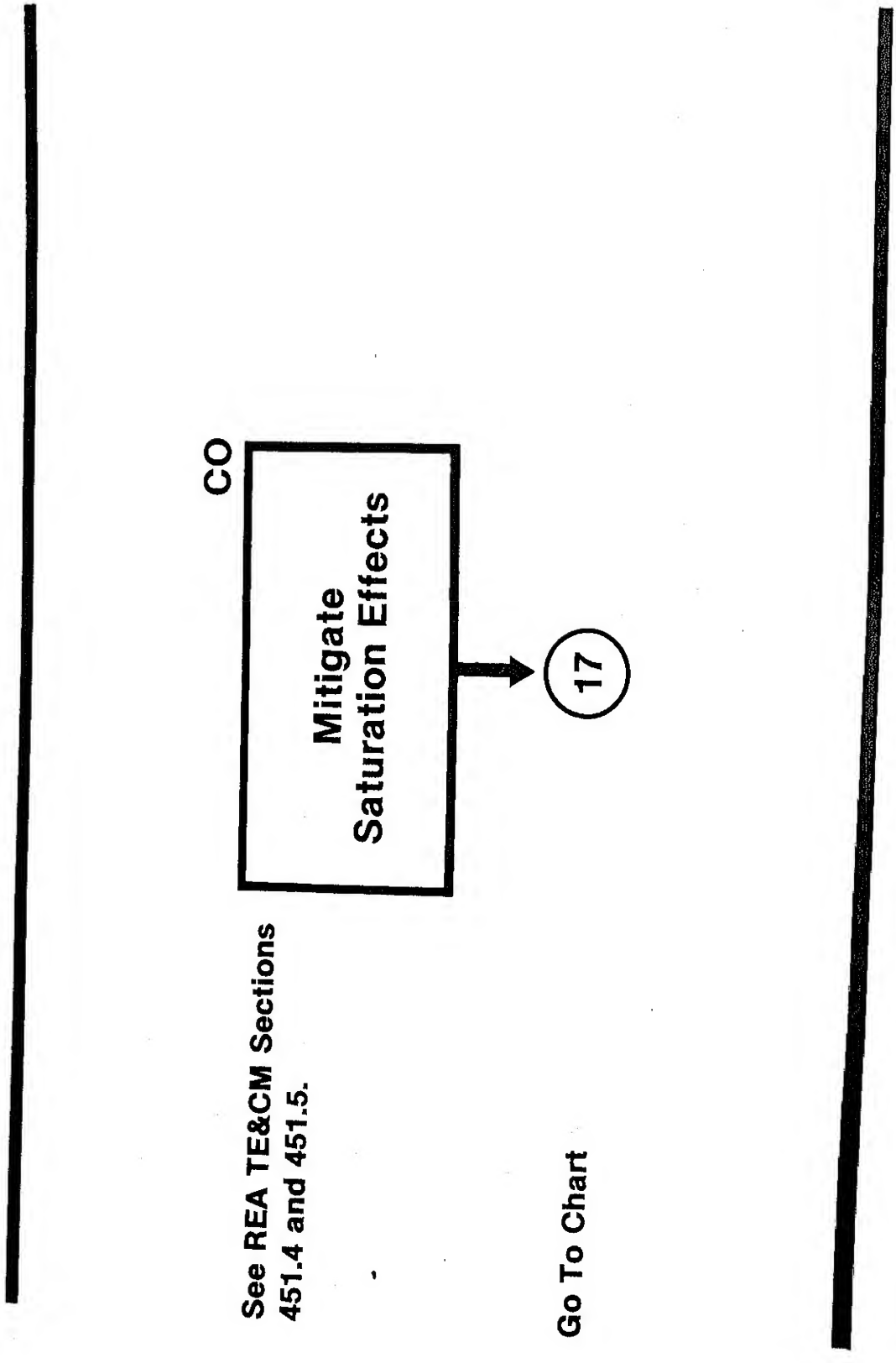

CO
Mitigate Saturation Effects
17
See REA TE&CM Sections 451.4 and 451.5.
Go To Chart

TABLE VI

For identification of an Open Shield (Based on 540 Hz)

Length-Kf.	22 GAUGE SHIELDS: 10mil CU															
	12 Pr.		18 Pr.		25 Pr.		50 Pr.		75 Pr.		100 Pr.		150 Pr.		200 Pr.	
	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.
1	0.9	0.1	0.9	0.1	0.9	0.1	0.9	–	0.8	–	0.8	–	0.8	–	0.8	–
2	2.2	0.4	2.1	0.3	2.1	0.2	2.0	0.2	2.0	0.1	2.0	0.1	1.9	0.1	1.9	0.1
3	3.3	0.7	3.2	0.6	3.2	0.5	3.1	0.3	3.0	0.2	3.0	0.2	2.9	0.1	2.9	0.1
4	4.1	1.0	4.1	0.8	4.0	0.7	3.9	0.5	3.8	0.4	3.8	0.3	3.7	0.2	3.6	0.2
5	4.8	1.2	4.7	1.0	4.7	0.9	4.6	0.6	4.5	0.5	4.4	0.4	4.3	0.3	4.3	0.2
6	5.4	1.5	5.3	1.2	5.2	1.1	5.1	0.8	5.0	0.6	5.0	0.5	4.9	0.4	4.8	0.3
7	5.8	1.7	5.7	1.4	5.7	1.2	5.6	0.9	5.4	0.7	5.4	0.6	5.3	0.4	5.2	0.3
8	6.2	1.8	6.1	1.6	6.1	1.4	5.9	1.0	5.8	0.7	5.8	0.7	5.6	0.5	5.6	0.4
9	6.5	2.0	6.4	1.7	6.4	1.5	6.2	1.1	6.1	0.8	6.1	0.7	5.9	0.5	5.9	0.4
10	6.8	2.2	6.7	1.9	6.6	1.6	6.5	1.2	6.4	0.9	6.3	0.8	6.2	0.6	6.1	0.5

1. If measured difference is nearly equal to (less than 50% greater) or less than the calculated difference, the shield can be considered acceptable.

2. If measured difference is more than 50% greater than the calculated difference the shield is probably partially open.

3. If measured difference is nearly equal to or greater than the value in the "10 Pr." column, the shield can be considered completely open.

NOTE: Use for Air Core, Filled, and Foam Insulated Filled Cables.

Chart 17

SUB

See REA TE&CM Section 452.2.

Measure Power Influence Harmonics and Analyze

Test configuration shown on Figure 5, Page 53R.

See REA TE&CM Sections 452 and 452.2.

Complete Additional Tests, as Required, to Verify Problem(s)

Go To Chart (18)

TABLE VII

For identification of an Open Shield (Based on 540 Hz)

Length-Kf.	19 GAUGE SHIELDS: 10mil CU															
	12 Pr.		18 Pr.		25 Pr.		50 Pr.		75 Pr.		100 Pr.		150 Pr.		200 Pr.	
	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.
1	1.0	0.1	1.0	0.1	1.0	0.1	0.9	–	0.9	–	0.9	–	0.9	–	0.9	–
2	2.5	0.4	2.5	0.3	2.5	0.2	2.4	0.1	2.3	0.1	2.3	0.1	2.2	0.1	2.2	0.1
3	4.0	0.7	3.9	0.6	3.9	0.5	3.7	0.3	3.7	0.2	3.6	0.2	3.5	0.1	3.5	0.1
4	5.2	1.1	5.1	0.9	5.1	0.7	4.9	0.4	4.8	0.4	4.8	0.3	4.7	0.2	4.6	0.2
5	6.2	1.4	6.1	1.1	6.1	1.0	5.9	0.6	5.8	0.5	5.7	0.4	5.6	0.3	5.6	0.2
6	7.0	1.6	6.9	1.4	6.9	1.2	6.7	0.7	6.6	0.6	6.5	0.5	6.4	0.4	6.3	0.3
7	7.7	1.9	7.6	1.6	7.6	1.4	7.3	0.8	7.3	0.7	7.2	0.6	7.1	0.4	7.0	0.4
8	8.3	2.1	8.2	1.8	8.1	1.5	7.9	1.0	7.8	0.8	7.8	0.7	7.6	0.5	7.6	0.4
9	8.8	2.3	8.7	2.0	8.7	1.7	8.4	1.1	8.3	0.9	8.3	0.7	8.1	0.5	8.1	0.5
10	9.3	2.5	9.2	2.1	9.1	1.8	8.9	1.2	8.8	1.0	8.7	0.8	8.5	0.6	8.5	0.5

1. If measured difference is nearly equal to (less than 50% greater) or less than the calculated difference, the shield can be considered acceptable.

2. If measured difference is more than 50% greater than the calculated difference the shield is probably partially open.

3. If measured difference is nearly equal to or greater than the value in the "10 Pr." column, the shield can be considered completely open.

NOTE: Use for Air Core, Filled, and Foam Insulated Filled Cables.

Chart 18

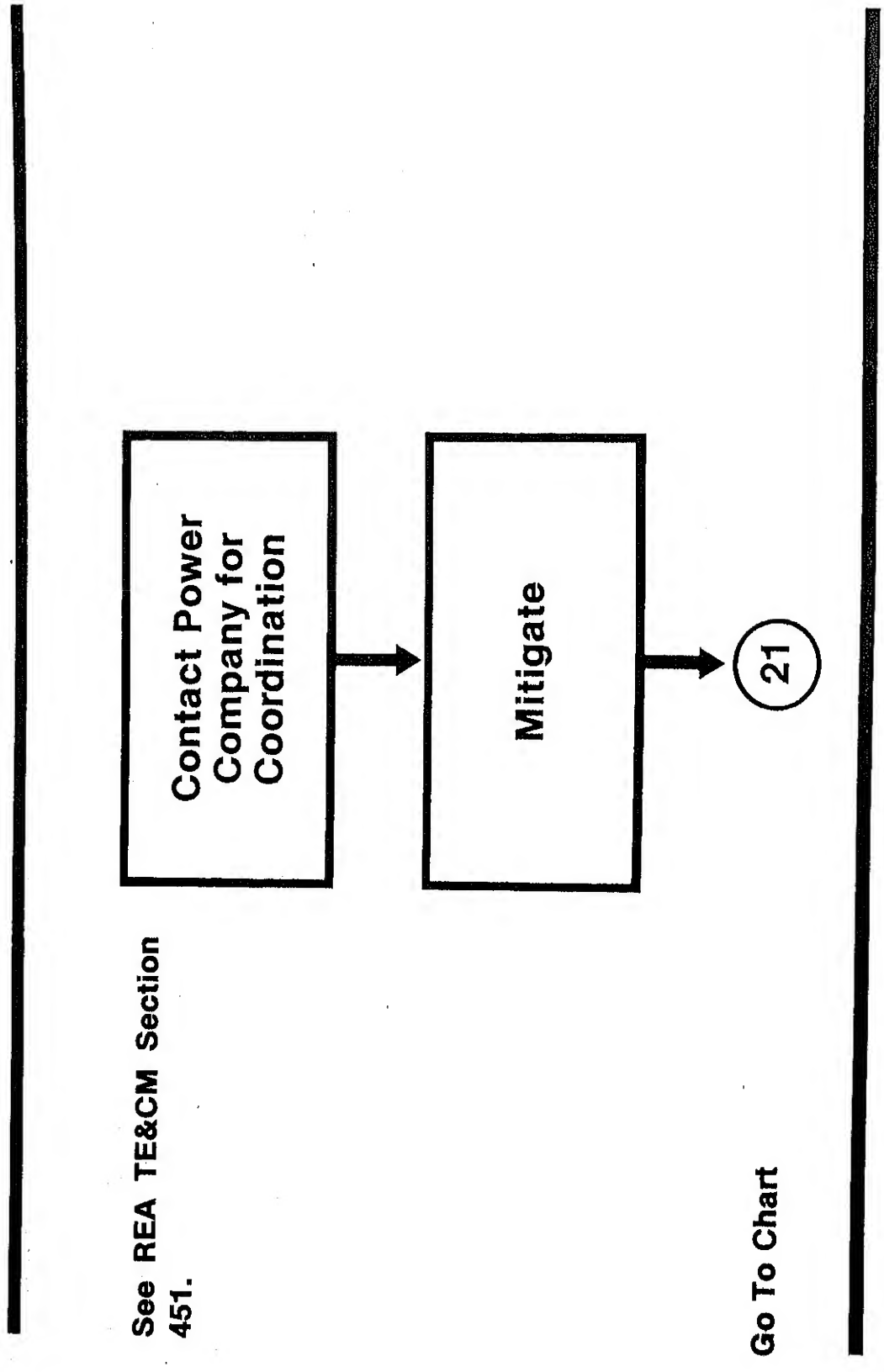

See REA TE&CM Section 451.
Contact Power Company for Coordination
Mitigate
21
Go To Chart

TABLE VIII

For identification of an Open Shield (Based on 540 Hz)

24 GAUGE SHIELDS: 6mil CCS & 6mil 194

Length-Kf.	12 Pr.		18 Pr.		25 Pr.		50 Pr.		75 Pr.		100 Pr.		150 Pr.		200 Pr.	
	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.
1	0.8	0.2	0.8	0.2	0.8	0.2	0.8	0.1	0.8	0.1	0.7	0.1	0.7	0.1	0.7	0.1
2	1.8	0.8	1.8	0.7	1.8	0.7	1.7	0.5	1.7	0.4	1.6	0.3	1.6	0.3	1.6	0.2
3	2.6	1.4	2.5	1.3	2.5	1.2	2.5	0.9	2.4	0.8	2.4	0.7	2.3	0.5	2.3	0.4
4	3.2	1.9	3.1	1.7	3.1	1.6	3.0	1.3	3.0	1.1	2.9	0.9	2.9	0.7	2.8	0.6
5	3.6	2.3	3.6	2.1	3.6	2.0	3.5	1.6	3.4	1.4	3.4	1.2	3.3	1.0	3.2	0.8
6	4.0	2.7	4.0	2.5	3.9	2.3	3.8	1.9	3.8	1.6	3.7	1.4	3.6	1.1	3.6	0.9
7	4.3	3.0	4.2	2.8	4.2	2.6	4.1	2.1	4.0	1.8	4.0	1.6	3.9	1.3	3.8	1.1
8	4.5	3.2	4.5	3.0	4.4	2.8	4.3	2.3	4.3	2.0	4.2	1.8	4.1	1.4	4.1	1.2
9	4.7	3.4	4.7	3.2	4.6	3.0	4.5	2.5	4.5	2.1	4.4	1.9	4.3	1.6	4.2	1.3
10	4.9	3.6	4.8	3.4	4.8	3.2	4.7	2.60	4.6	2.3	4.6	2.0	4.5	1.7	4.4	1.4

1. If measured difference is nearly equal to (less than 50% greater) or less than the calculated difference, the shield can be considered acceptable.

2. If measured difference is more than 50% greater than the calculated difference the shield is probably partially open.

3. If measured difference is nearly equal to or greater than the value in the "10 Pr." column, the shield can be considered completely open.

NOTE: Use for Air Core, Filled, and Foam Insulated Filled Cables.

Chart *19

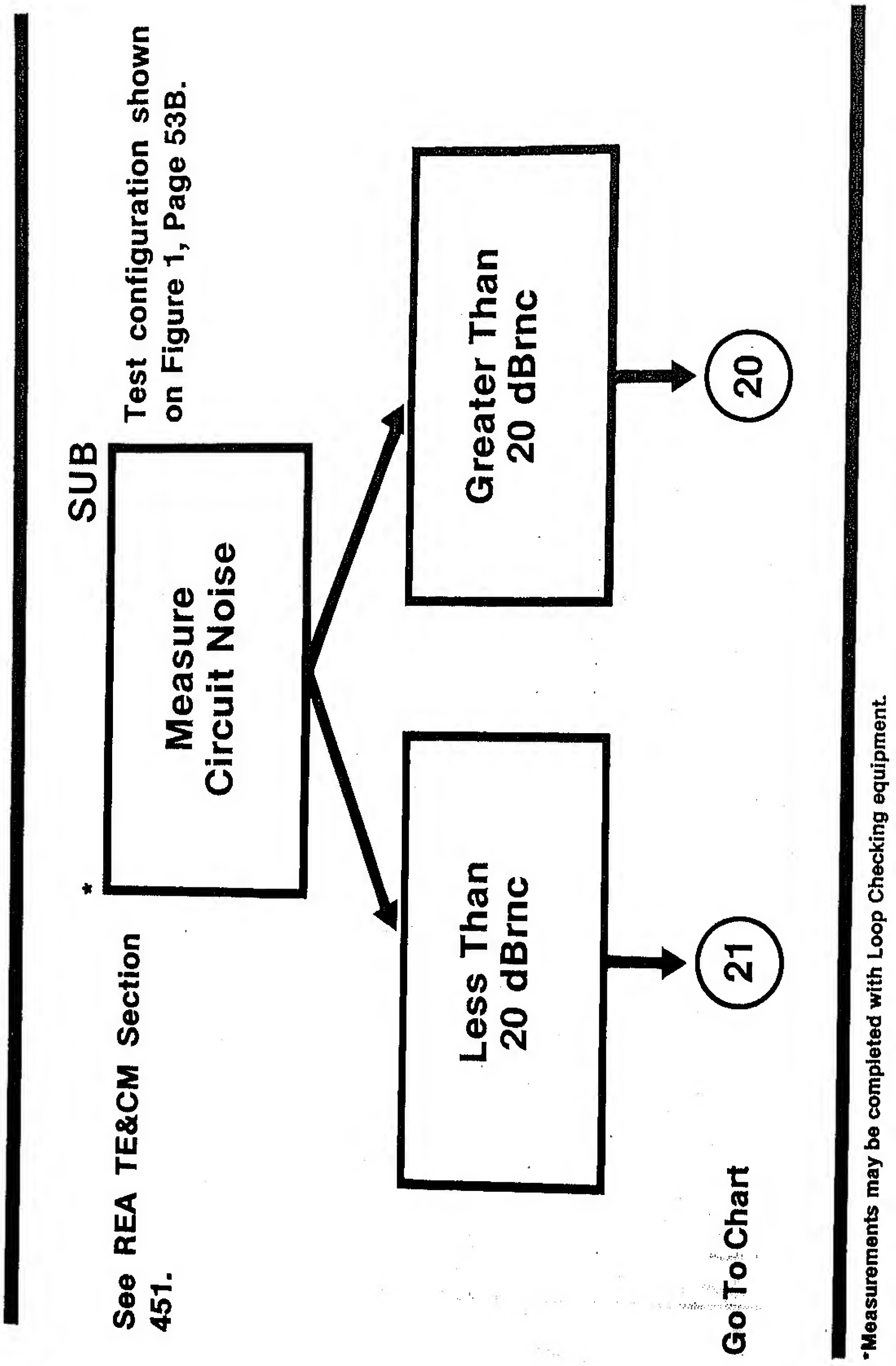

SUB
Test configuration shown on Figure 1, Page 53B.
Measure Circuit Noise
Greater Than 20 dBrnc
20
Less Than 20 dBrnc
21
See REA TE&CM Section 451.
Go To Chart
*Measurements may be completed with Loop Checking equipment.

TABLE IX

For identification of an Open Shield (Based on 540 Hz)

Length-Kf.	22 GAUGE SHIELDS: 6mil CCS & 6mil 194															
	12 Pr.		18 Pr.		25 Pr.		50 Pr.		75 Pr.		100 Pr.		150 Pr.		200 Pr.	
	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.
1	0.9	0.2	0.9	0.2	0.9	0.2	0.9	0.1	0.8	0.1	0.8	0.1	0.8	0.1	0.8	0.1
2	2.2	0.9	2.1	0.8	2.1	0.7	2.0	0.5	2.0	0.4	2.0	0.4	1.9	0.3	1.9	0.2
3	3.3	1.6	3.2	1.4	3.2	1.3	3.1	1.0	3.0	0.8	3.0	0.7	2.9	0.5	2.9	0.4
4	4.1	2.2	4.1	2.0	4.0	1.8	3.9	1.4	3.8	1.1	3.8	1.0	3.7	0.8	3.6	0.7
5	4.8	2.8	4.7	2.5	4.7	2.2	4.6	1.8	4.5	1.4	4.4	1.3	4.3	1.0	4.3	0.9
6	5.4	3.2	5.3	2.9	5.2	2.6	5.1	2.1	5.0	1.7	5.0	1.6	4.9	1.2	4.8	1.0
7	5.8	3.6	5.7	3.3	5.7	2.9	5.6	2.4	5.4	2.0	5.4	1.8	5.3	1.4	5.2	1.2
8	6.2	3.9	6.1	3.6	6.1	3.2	5.9	2.7	5.8	2.2	5.8	2.0	5.6	1.6	5.6	1.4
9	6.5	4.2	6.4	3.9	6.4	3.5	6.2	2.9	6.1	2.4	6.1	2.2	5.9	1.7	5.9	1.5
10	6.8	4.5	6.7	4.1	6.6	3.7	6.5	3.1	6.4	2.5	6.3	2.3	6.2	1.9	6.1	1.6

1. If measured difference is nearly equal to (less than 50% greater) or less than the calculated difference, the shield can be considered acceptable.

2. If measured difference is more than 50% greater than the calculated difference the shield is probably partially open.

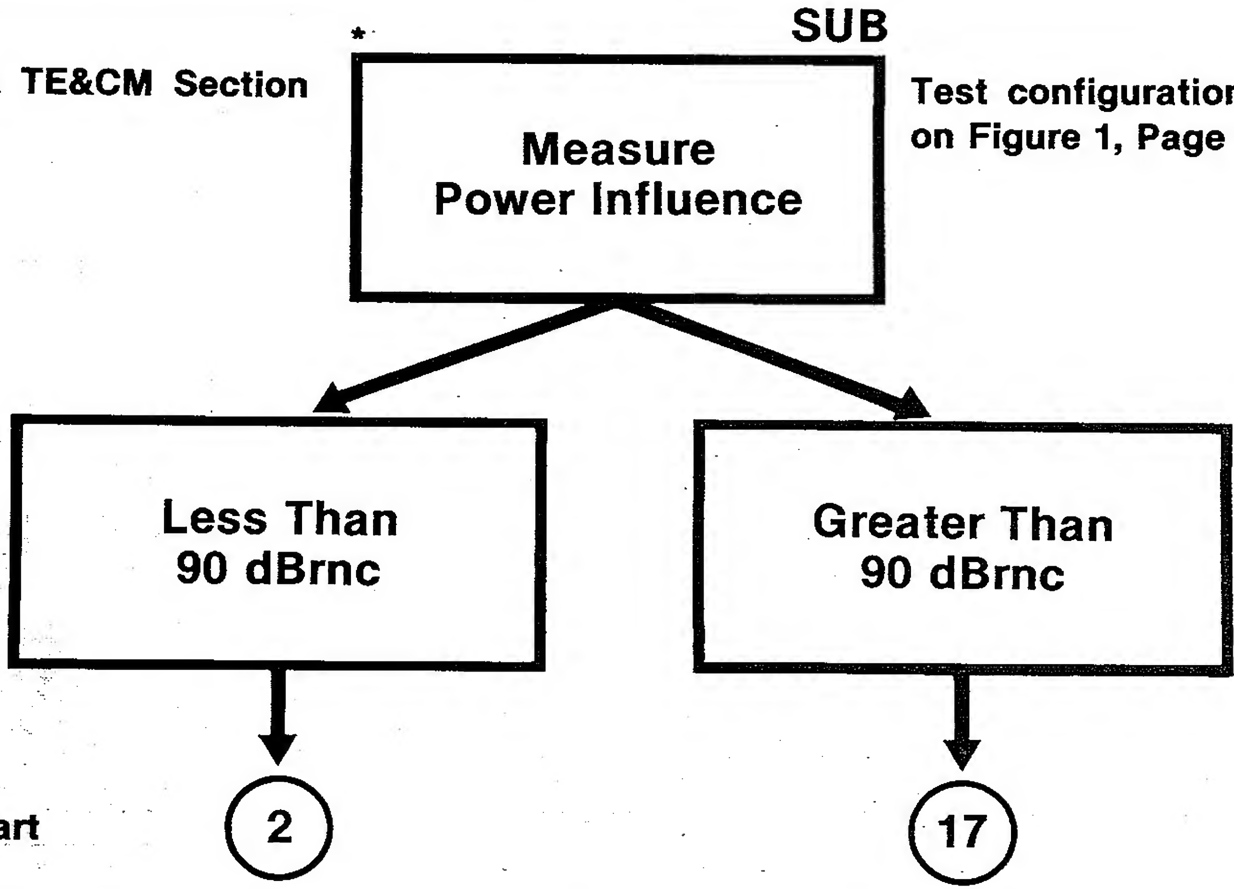
3. If measured difference is nearly equal to or greater than the value in the "10 Pr." column, the shield can be considered completely open.

NOTE: Use for Air Core, Filled, And Foam Insulated Filled Cables.

Chart *20

See REA TE&CM Section 451.

Test configuration shown on Figure 1, Page 53B.



Go To Chart

*Measurements may be completed with Loop Checking equipment.

TABLE X

For identification of an Open Shield (Based on 540 Hz)

Length-Kf.	19 GAUGE SHIELDS: 6mil CCS & 6mil 194															
	12 Pr.		18 Pr.		25 Pr.		50 Pr.		75 Pr.		100 Pr.		150 Pr.		200 Pr.	
	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.	10 Pr.	Diff.
1	1.0	0.2	1.0	0.2	1.0	0.2	0.9	0.1	0.9	0.1	0.9	0.1	0.9	0.1	0.9	-
2	2.5	0.9	2.5	0.8	2.5	0.7	2.4	0.5	2.3	0.4	2.3	0.3	2.2	0.3	2.2	0.2
3	4.0	1.8	3.9	1.5	3.9	1.3	3.7	0.9	3.7	0.8	3.6	0.7	3.5	0.5	3.5	0.5
4	5.2	2.5	5.1	2.2	5.1	1.9	4.9	1.4	4.8	1.2	4.8	1.0	4.7	0.8	4.6	0.7
5	6.2	3.2	6.1	2.8	6.1	2.5	5.9	1.8	5.8	1.5	5.7	1.3	5.6	1.0	5.6	0.9
6	7.0	3.7	6.9	3.3	6.9	3.0	6.7	2.1	6.6	1.8	6.5	1.6	6.4	1.2	6.3	1.1
7	7.7	4.2	7.6	3.7	7.6	3.4	7.3	2.5	7.3	2.1	7.2	1.9	7.1	1.5	7.0	1.3
8	8.3	4.7	8.2	4.1	8.1	3.8	7.9	2.7	7.8	2.4	7.8	2.1	7.6	1.6	7.6	1.5
9	8.8	5.00	8.7	4.5	8.7	4.1	8.4	3.0	8.3	2.6	8.3	2.3	8.1	1.8	8.1	1.6
10	9.3	5.4	9.2	4.8	9.1	4.4	8.9	3.2	8.8	2.8	8.7	2.5	8.5	2.0	8.5	1.8

1. If measured difference is nearly equal to (less than 50% greater) or less than the calculated difference, the shield can be considered acceptable.

2. If measured difference is more than 50% greater than the calculated difference the shield is probably partially open.

3. If measured difference is nearly equal to or greater than the value in the "10 Pr." column, the shield can be considered completely open.

ore, Filled, and Foam Insulated Filled Cables.

Chart *21

SUB

See REA TE&CM Section 451.

* **Measure Power Influence & Circuit Noise to Confirm Mitigation**

Test configuration shown on Figure 1, Page 53B.

*Measurements may be completed with Loop Checking equipment.

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